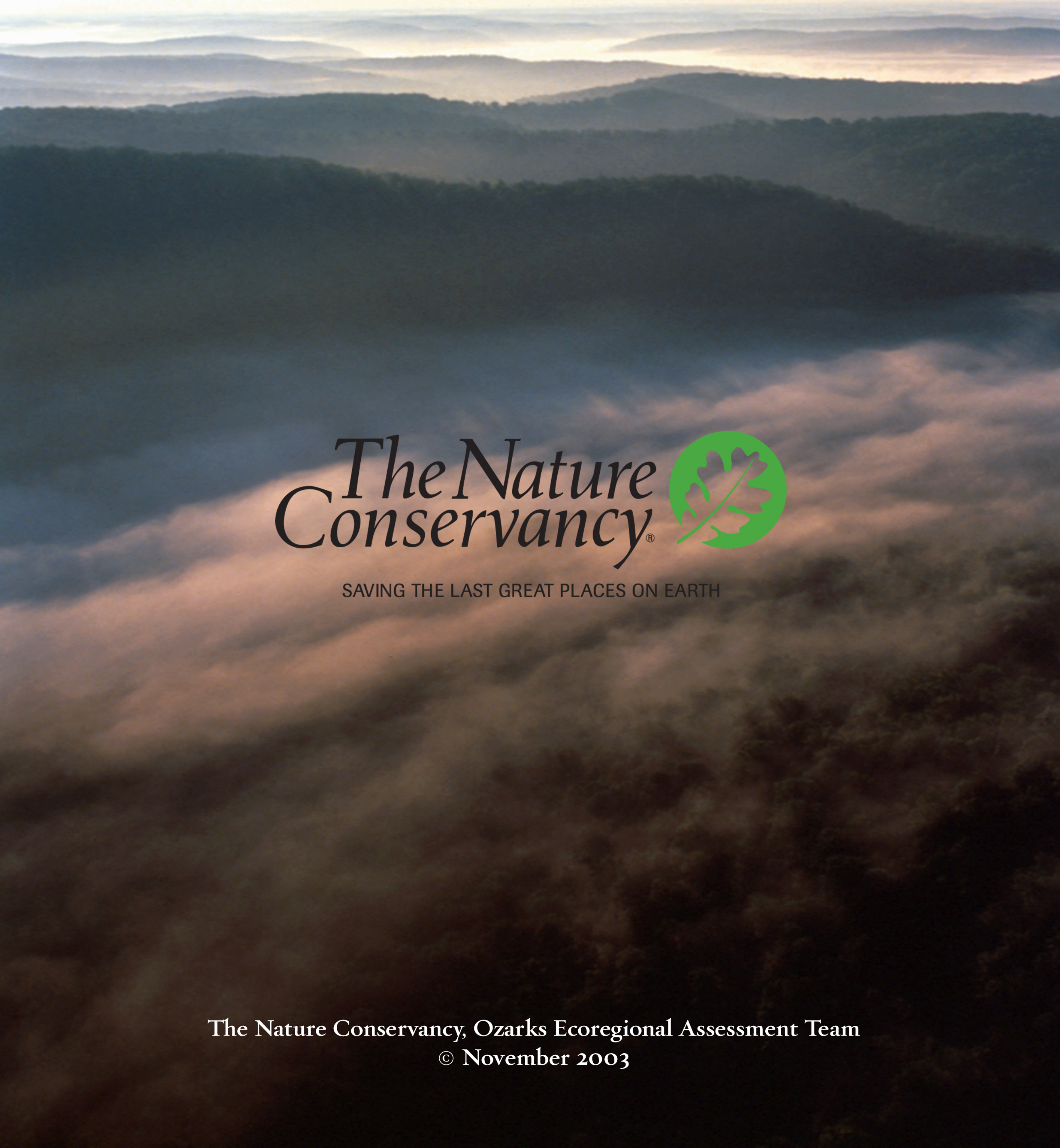
Ozarks Ecoregional Conservation Assessment



The Nature Conservancy

SAVING THE LAST GREAT PLACES ON EARTH

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The Mission of The Nature Conservancy
is to preserve the plants, animals,
and natural communities
that represent the diversity of life on earth
by protecting the lands and waters they need to survive

Cover photo by Frank Oberle

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1. Executive Summary

An assessment was conducted for the Ozarks ecoregion to determine the spatial configuration that would most efficiently conserve viable examples of all globally significant biodiversity features. This assessment identified the globally significant species, natural communities, and ecological systems in the ecoregion, established viability criteria for occurrences of these features and developed representation and selection criteria for sustainable conservation of these features.

The Ozarks ecoregion encompasses nearly 34 million acres in parts of Missouri, Arkansas, Oklahoma, Illinois and a small corner of Kansas. Along with the Ouachita region to the south, the Ozarks form the only significant highland region in mid-continental North America. Parts of this region have been continually exposed for at least 225 million years. Because of high habitat diversity and antiquity of the landscape, Ozark biota are characterized by an unusually high level of species disjunctions and endemism, with more than 160 endemic species documented from the ecoregion.

Starting in 1998, a multi-organizational core team, including representation from each of the four states with meaningful area within the Ozarks, began to develop this assessment. The decision was made at the start of the process to involve representatives from partner organizations as part of the core team. The core team worked with a large number of organizations and individuals at all stages of the assessment project. An initial task of the assessment was to derive a list of the ecological targets — species, natural communities, and ecological systems of global conservation significance. Once the ecological targets were determined, each target was analyzed for various conservation-relevant attributes, such as pattern of occurrence.

Conservation goals for target capture were developed to address issues of necessary redundancy and representational stratification. Natural community and ecological system targets were stratified across a series of subsectional hierarchies established for each target class: terrestrial, aquatic, and karst. The assessment also developed viability criteria for each target type, including a preliminary threats analysis, and analyzed target occurrences in the ecoregion for viability, ensuring that the most viable occurrences were identified in the selection process.

These data were synthesized into a spatial assessment with supporting data that provides an explicit rendering of the most significant areas of the Ozarks from a biodiversity conservation perspective. The resulting portfolio encompasses 179 total sites, including 31 landscape-scale terrestrial areas, 43 small scale terrestrial sites, 44 aquatic sites, and 61 karst areas. The terrestrial and karst sites encompass a total of 5.7 million acres, or about 16.5% of the total area of the Ozarks. Aquatic priority sites include 3,179 stream miles and their accompanying watersheds; this represents about 19% of the total stream reaches within the Ozarks. These data also demonstrate the critical importance of Ozark sites, such as the Buffalo River in Arkansas and the Current River in Missouri, which between them contain the world's best known populations of 34 aquatic species of global conservation significance.

A preliminary review of site-by site threats was conducted to determine priority multi-site threats, and the primary sources of these threats across the ecoregion. Taken with the spatial information and supporting data generated by this assessment, the resulting product allows rapid evaluation of the most biologically significant areas within the ecoregion, establishes a goal for long term conservation, provides the foundation for developing and implementing conservation strategies at both the regional and local scales, and documents the disproportionate global significance of Ozark biodiversity relative to the area of the ecoregion within North America.

2. Introduction

The mission of The Nature Conservancy
is to preserve the plants, animals, and natural communities
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To efficiently accomplish this mission and ensure that conservation resources are effectively deployed for sustainable conservation of priority targets, The Nature Conservancy has committed to plan and implement conservation at an ecoregional scale (TNC 1996). An ecoregion can be broadly defined as an area where a commonality of physical, biotic and pre-historic factors, and natural process regimes create a region of biological cohesiveness.

Ecoregions typically occur on scales of thousands of square miles (millions of hectares) or more. Within the United States, there are eighty ecoregions, and within each of these, as well as for all global ecoregions, the Conservancy's goal is to ensure the "long term survival of all viable native species and community types through the design and conservation of portfolios of sites within ecoregions" (Groves et al. 2000).

An ecoregional assessment thus serves as a conservation blueprint, identifying those elements of a region's biological features that are of conservation significance from a biodiversity perspective, and providing spatial information about where within the ecoregion these conservation targets are best represented in sustainable arrays. An ecoregional assessment answers the questions of what is important from a perspective of global biodiversity conservation, and what is the least area of the landscape that must be the subject of conservation attention to ensure sustainable conservation of this biodiversity.

Although the unique cultural, historical, biological, and physical attributes of each ecoregion require different approaches to assessment and planning, all ecoregional assessments have a common set of key components as enumerated below.

Ozarks ecoregional assessment key planning steps and products:

1. Determine conservation targets [derive an enumeration of the species, natural communities and ecological systems of conservation concern within the ecoregion].
2. Set conservation goals [determine how many and what spatial distribution of targets is necessary to sustain all the elements of ecoregional biodiversity through a minimum of 100 years].
3. Determine target occurrences [develop integrated spatial data set with locality information for conservation targets within the ecoregion].
4. Assess viability [determine criteria for sustainability of targets, and assess all target occurrences for potential viability].
5. Assemble portfolio [develop a spatial data set of most efficient representation to meet conservation goals for all targets].
6. Assess completeness [test target capture and efficiency, and revise portfolio accordingly in a multistep iterative process].

7. Compile synoptic threat assessment [determine potential stresses and sources likely to degrade target occurrences within the ecoregion and the feasibility of threat abatement].
8. Develop an action plan and implementation strategies [determine when and where to initiate conservation activity, and what multi-site and cross boundary strategies and threat abatement strategies have the highest potential leverage and impact].

Each of these steps are discussed in further detail in the following sections. The resultant product provides a template of what is fundamentally irreplaceable from a global conservation perspective within the ecoregion, and the best spatial representation of a conservation design to ensure sustainability of these elements. Just as importantly, the assessment also identifies those areas of the landscape where, from a global biodiversity perspective, it would be less justifiable or efficient to direct conservation resources.

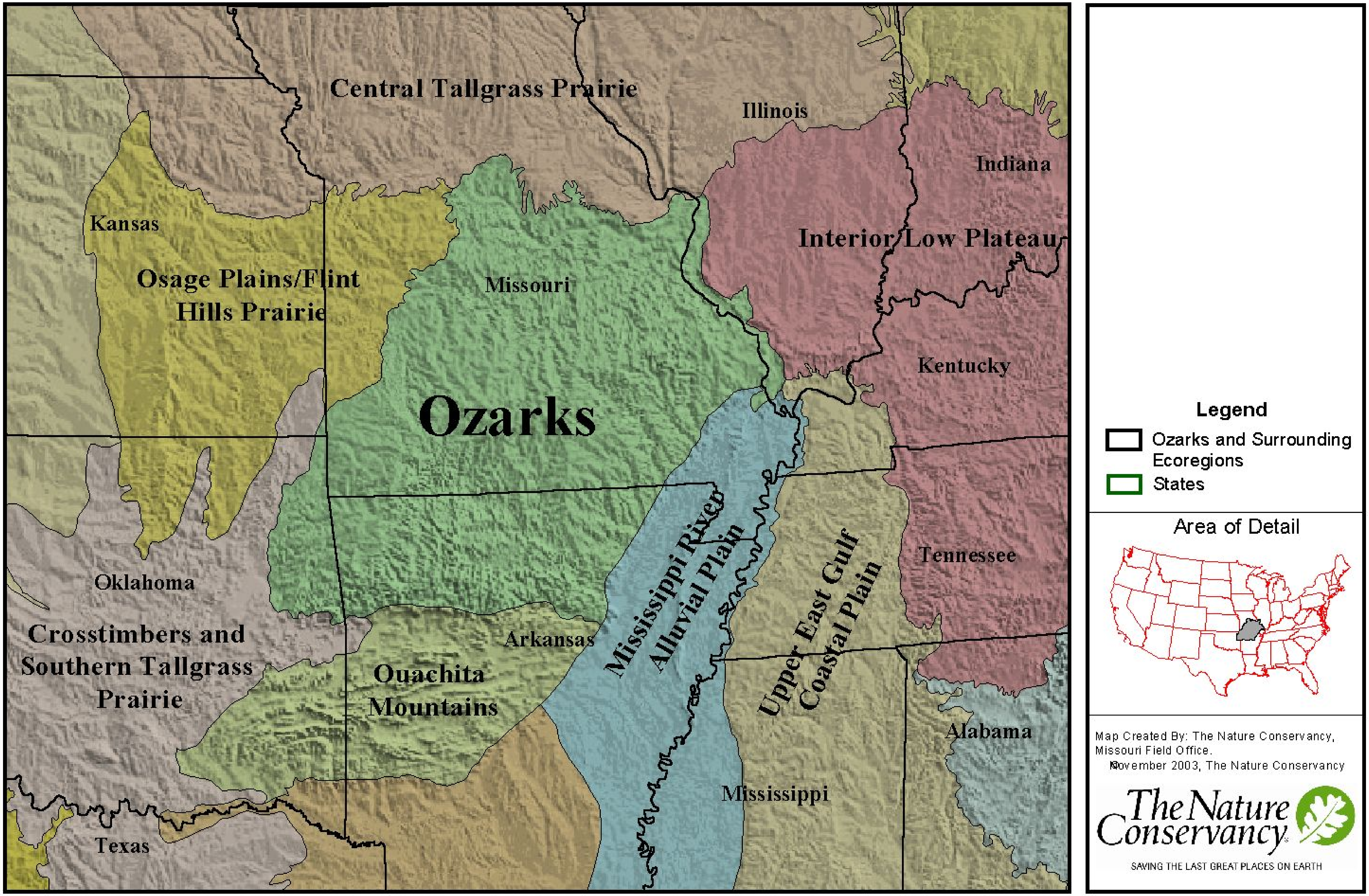
Thus, an ecoregional assessment enumerates what is biologically important in an ecoregion, and where this biodiversity can be most efficiently and sustainably conserved. It does not provide explicit information about site-based conservation attributes, which are the purview of site conservation planning and implementation.

Activities related to Ozarks ecoregional conservation began with informal discussion and collaborations among the Arkansas and Missouri operating units of the Conservancy in the early 1990's, using available Natural Heritage Program information to identify biologically significant areas of the Ozarks, such as the Lower Ozark project area (TNC 1993). Valuable additional data related to physical, biological, and cultural aspects of the ecoregion were developed through the Ozark-Ouachita Highlands Assessment (USDA Forest Service 1999). This analysis resulted in an integrated assessment of the Interior Highlands spearheaded by the USDA Forest Service, with a broad collaboration of outside experts, organizations, and agencies, including active participation from three Nature Conservancy programs in the assessment region (Arkansas, Missouri, Oklahoma).

Formal ecoregional assessment activity commenced in 1998 with a core team consisting of both Conservancy staff and staff from key partner agencies. The core team, with assistance from numerous specialists, also served as the technical and design team for the assessment. The assessment team was indirectly overseen by an informal steering committee consisting of the Arkansas and Missouri state directors. Ecoregional data assembly and assessments were conducted from 1998 through 2001, and the iterative assembly and testing of the portfolio resulting in the final portfolio design was completed in 2002. Implementation plan development commenced in 2002. In conceptual approach, planning steps and sequences generally followed that enumerated by Ostlie and Haferman (1999).

Throughout the process, the assessment benefited from a broad collaborative input by a diverse group of experts, many of whom are acknowledged elsewhere in this report. The strength of this assessment is a direct result of additional information and data that was freely shared with the core team, resulting in a far better set of data on which to base conservation decisions than would otherwise have been available.

Figure 1. Ozarks Ecoregion



3. Ozarks Ecoregional Overview

The Ozark region has long been recognized as a geologically, physiographically, ecologically, and culturally distinct area of North America. In conjunction with the Ouachita region to the south, the Ozarks comprise the only highland in midcontinental North America, and the only significant topographic relief between the Appalachians and the Rocky mountains.

This region is characterized by a diversity of terrestrial, aquatic, and karst habitats, ranging from glades and tallgrass prairies to both coniferous and deciduous woodlands and cypress swamps, as well as fens, sinkholes, sloughs, and a suite of clear-flowing streams and rivers fed by an abundance of springs of all magnitudes.

Encompassing 13.7 million hectares (34.3 million acres), the Ozarks ecoregion includes portions of five states, with the majority of the region occurring within Missouri (67%) and Arkansas (24%) and smaller portions in Oklahoma (17%), Illinois (2%) and Kansas (0.1%). The Ozarks span a maximum of 270 miles (450 km) of north/south extent, and a maximum east/west extent of 340 miles (540 km). As shown in Figure 1, six other ecoregions, ranging in character from tallgrass prairie landscapes to humid forested wetland systems, border the Ozarks ecoregion.

High levels of topographic, geologic, edaphic and hydrologic diversity exist throughout the Ozarks, resulting in a wide range of habitat types. This is a region of rugged uplands with copious exposed rocks and variable soil depths. The landscape in various terrestrial subsections of the Ozarks ranges from extensive areas of karst terrain on irregular plains, to highly dissected regions with steep hills and deeply entrenched valleys, as well as limited areas of ancient low mountains with elevations up to 925 meters (3000 feet). There are also smaller, linear areas of alluvial terrain and major riparian features.

Bedrock geology of the ecoregion includes exposures of Precambrian igneous rocks in the eastern part of the Missouri Ozarks surrounded by alternating zones of Paleozoic sandstone and carbonate sedimentary rocks. Structurally, the Ozarks consist of a dome that has been slowly uplifted and eroded, resulting in a distinct landscape pattern. The oldest igneous rocks are exposed at the center of the uplift in southeast Missouri and surrounded by regions of Cambrian- and Ordovician-aged shallow water carbonates and beach sandstone strata. Further from the center are areas of younger Mississippian sedimentary rocks, including limestones and limited areas of riparian-derived freshwater sandstones (Nigh and Schroeder 2002).

Dominant soils consist of Alfisols and Ultisols. The Alfisols, predominant in the less dissected terrestrial subsections, are thin loams with a clay component in the subsurface, and are generally thought to have formed under timber and some prairie vegetation types. Ultisols, predominant in the more rugged and dissected terrestrial subsections of the Ozarks, can in many ways be considered a more leached, weathered version of alfisols, with a much lower component of basic cations. Average precipitation in the Ozarks ranges from 39-52 inches (99-132 cm), with mean annual temperatures ranging from 54-63 °F (12-17 °Celcius). The average frost free growing season ranges from 180-208 days.

A major contributing factor to the region's extreme biological diversity is that parts of the Ozarks have been continuously available for plant and animal life since the late Paleozoic some

230 million years ago, constituting perhaps the oldest continuously exposed land mass in North America, and one of the oldest on earth. Plants have presumably inhabited these rugged uplands since the origin of the modern angiosperms some 100 million years ago. Because of their central location within the continent, the Ozarks have on multiple occasions served as a refugium for organisms buffeted by climatic shifts associated with glacial and geologic events. The high levels of microhabitat diversity, influx of biota from divergent regions, and extreme antiquity of the landscape have combined to both sustain relictual populations and allow the development of new species, making the Ozarks a center of endemism in North America.

None of the four major continental glaciation events of the past two million years extended into the Ozarks. At the maximal extent of Wisconsin glaciation some 15,000 years ago, the climatic effects of a massive ice sheet extending into what is now Iowa resulted in a boreal climate through much of midcontinental North America. At that time, the vegetation of the Ozarks was a combination of spruce-fir forests and jack pine parklands (Delcourt et al. 1986).

Coincident with or preceding the glacial retreat, there has been a more or less continuous inhabitancy of the region by human cultures. These people had to secure all the necessities of survival from the local environment on a year round basis without mercantile exchange from remote areas. The fact that such cultures not merely survived, but developed art, mythology, ceremony, religion, and other accoutrements of highly developed societies, testifies to their superb abilities to manage and interact with the Ozark environment.

One of the most pervasive and effective tools available to early human populations in the region was wildland fire. An irrefutable body of evidence exists that the biological landscape of the Ozarks reflects the effects of millennia of frequent, low intensity, dormant season fires set by humans (e.g. Ladd 1991, Guyette & Cutter 1991). At the initiation of European settlement of the region, predominate Native Americans in the Ozarks were the Osage. Parts of the eastern and southeastern Ozarks were home to the Quapaw.

Thus, the pre-Eurosettlement vegetation in the Ozarks had been influenced since the end of the glacial period by an ongoing aboriginal fire regime. This vegetation consisted of a mosaic of matrix communities dominated by open woodland types, with various combinations of oaks and shortleaf pine as the principle overstory dominants in the uplands. Although Ozark woodlands are significantly different from the extensive deciduous woodlands extending eastward to the Atlantic coast, the Ozarks represent the westernmost extension of this eastern deciduous woodland formation that dominated much of eastern North America prior to European settlement. Extensive areas of tallgrass prairie occurred in the Ozarks, especially in the western terrestrial subsections (Schroeder 1981). Embedded within these matrix vegetation types was a diverse assemblage of small and large patch natural communities, including various types of fens, forests, wetlands, fluvial features and both carbonate and siliceous glades. The Ozarks ecoregion contains the largest extent of glade communities in North America (Nelson and Ladd 1980).

As a direct result of all of these factors, the Ozarks support a diversity of natural communities and associated biota unlike anywhere else on earth. Many plants and animals in the Ozarks are relict populations of organisms whose modern ranges are otherwise remote from the region. A combination of habitat diversity, landscape position, and glacial history has resulted in a large number of species with diverse biogeographic affinities attaining the limits of their ranges within the Ozarks. For example, an evaluation of the Lower Ozark region of southeastern Missouri and northeastern Arkansas (predominately in the Central Plateau and Current River Hills terrestrial subsections) revealed that an astounding 17% of the areas vascular flora attained a limit of their global range in the Ozarks (TNC 1993).

The Ozarks also constitute a center of endemism for temperate biota in divergent organismal groups including vascular plants, lichens, fish, mollusks, and crayfish. Although not attaining levels of endemism associated with certain tropical systems, at least 200 taxa of plants and animals are known to be endemic to the Ozarks and/or Ouachitas (Allen 1990), despite a lack of disciplined biological inventory through most of the region, especially among more cryptic organismal groups. For these reasons, the area has long been recognized by conservation practitioners for its biodiversity and conservation significance.

Although significantly impacted by anthropogenic activities associated with modern society and hosting a human population of more than three million people, large areas of the Ozarks remain in native vegetation cover. Timber, tourism, and agriculture are major economic factors in the region, with a rapidly increasing influx of retirees in recent years. Overall population trends are upward in the region. Average education and income levels throughout the Ozarks are generally lower than national averages, and 29 Ozark counties are classified as "persistent poverty" counties (USDA Forest Service 1999). Critical threats to biodiversity across the region include altered fire regimes, altered hydrological regimes, habitat conversion and associated exotic species invasion, habitat fragmentation, and non-point-source pollution.

The Ozarks ecoregion can be conceptually divided into different subunits to accommodate sub-ecoregional variability based on biophysical processes and biogeographic patterns of different functional groups of biota. Thus, as described below, the Ozarks are logically divisable into various subsectional classification systems depending on whether the focus is based on terrestrial, karst, or surface aquatic systems and biota. Each of these subsectional classification systems are vital as a basis for effective conservation planning.

Terrestrial Subsections

From a terrestrial perspective, Keys et al. (1995) divide the Ozarks into two sections, the Boston Mountains section forming the southern border of the ecoregion in Oklahoma and Arkansas, and the Ozark Highlands section comprising the majority of the Ozarks. These sections are further divided into subsections, based on regions typically of 2,000 square miles (5,000 square kilometers) or more that have similarities among geologic and edaphic substrates, landform and topography, local climate, natural process regime and presettlement vegetation patterns. As shown in Figure 2 and summarized in Table 1, there are 17 distinct terrestrial subsections in the Ozark Highlands, and two terrestrial subsections in the Boston Mountains. Detailed characterizations of these nineteen Ozark terrestrial subsections are provided in Nigh and Schroeder (2002) and Keys et al. (1995).

Figure 2. Ozarks Ecoregion Terrestrial Subsections

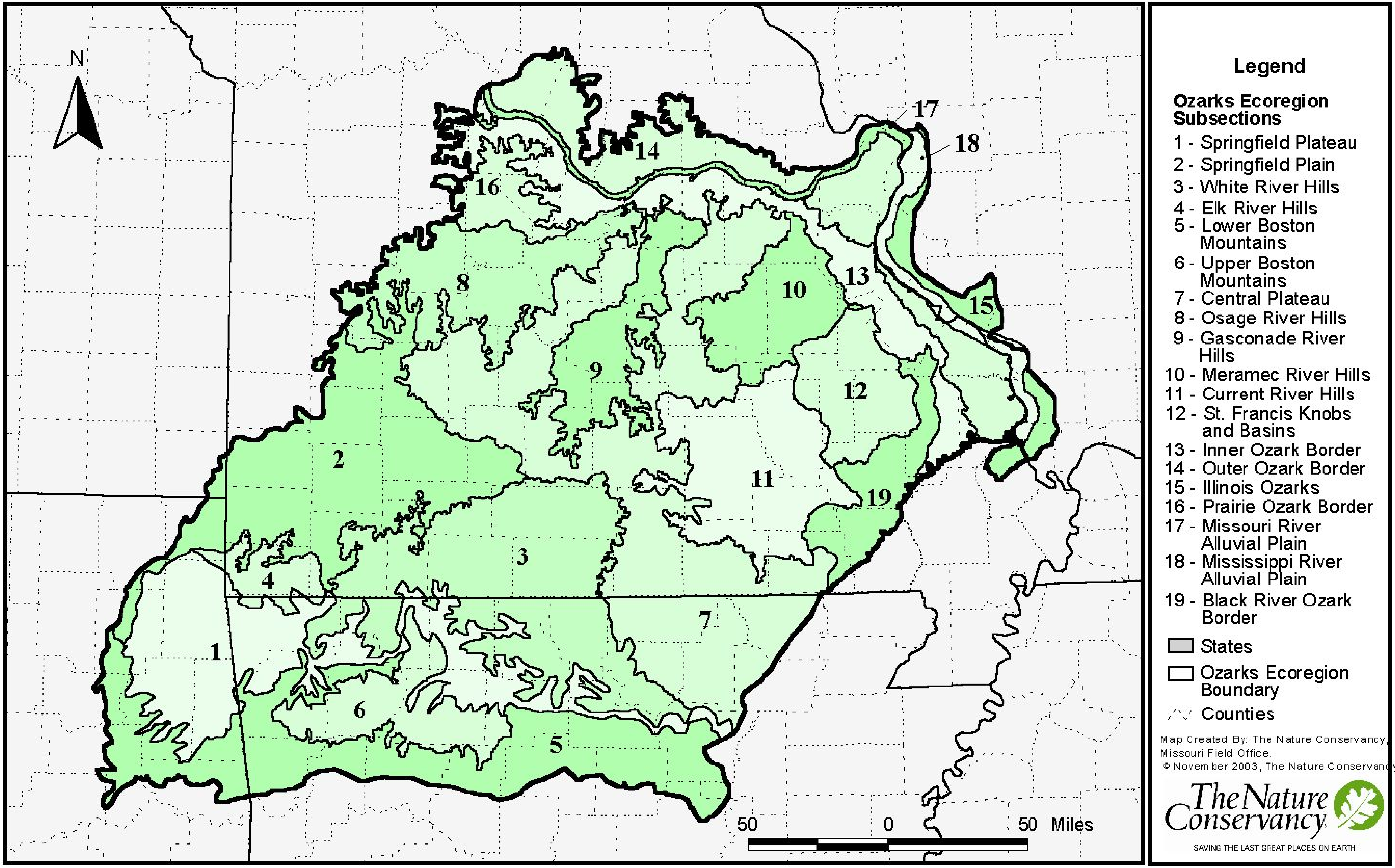


Table 1. Synopsis of Ozark Terrestrial Subsections
Subsections are listed in alphabetical order, preceded by their corresponding map numbers.

Subsection	Topography	Substrate	Characteristic Ecological System
19-Black River Ozark Border	Moderately dissected hills with locally steep rocky slopes and moderate local relief (up to 300 feet)	Bedrock is thick-bedded Ordovician dolomites and sandstones with abundant chert; soils are primarily cherty silt loams and clay pan soils with a loess component	Pine and pine-oak woodlands, with regions of mixed oak woodlands and Post Oak flatwoods on broad upland flats; scattered glades, fens, and sinkhole ponds
5-Lower Boston (= Boston Hills)	Moderately to highly dissected high hills with steep slopes and significant local relief (up to 1000 feet)	Pennsylvanian thick-bedded (Akota) sandstones, with local, abundant shale and chert; soils are generally shallow and rocky, consisting primarily of silt loams and sandy loams.	Large scale complex of pine, pine-oak, and mixed oak and oak hickory woodlands and acid soils, with frequent cliffs
6-Upper Boston (= Boston Mountains)	Highly dissected low mountains with high local relief and excessively steep slopes		Rugged landscape with complex of pine, pine-oak, and mixed oak and oak hickory woodlands grading into forests in more dissected terrain and ravines, with frequent cliffs, seeps, and small glade openings.
7-Central Plateau	Primarily an irregular, broad flat plain with minimal local relief and occasional steep slopes associated with major drainages	Characterized by Ordovician bedrock - primarily thick-bedded dolomites, with some significant sandstone exposures; soils are primarily deep, with a thin loess component, and fragipans are common	A complex intercalated mosaic of oak woodland, oak savanna, and tallgrass prairie
11-Current River Hills	Highly dissected landscape associated with the drainage basins of the Current, Eleven Point, and Black rivers, with moderate to high local relief	Primarily Ordovician and Cambrian dolomites, with limited Ordovician sandstone, and one area of precambrian igneous knobs; soils are copiously rocky, and primarily derived as weathering products from the base rock, with limited areas of fragipan	Diverse timbered mosaic, with open grassy woodlands on more gentle uplands, and denser woodlands and forests in heavily dissected regions - including pine woodland/forest complex, pine-oak, and acid oak woodlands and smaller areas of forest; mesophytic talus and bottomland woodlands in deeply dissected stream valleys; frequent dolomite glades, fens, large springs, bluffs, and sinkhole ponds

Subsection	Topography	Substrate	Characteristic Ecological System
4-Elk River Hills	Highly dissected drainage basin with abundant narrow ridges and ravines, steep slopes, and frequent large bluff exposures	Predominately cherty limestones of the Ordovician Burlington formation, with Ordovician dolomites in the deepest dissections; soils predominately derived from cherty limestones	Open oak woodland and extensive oak savanna with prominent and diverse grassy ground layer, and associated oak pine woodlands on xeric cherty ridges; small limestone glades, prairie openings, and frequent small springs
9-Gasconade River Hills	Highly dissected, topographically complex, steeply sloping landscape associated with the Gasconade River system	Ordovician aged dolomites and some similar aged sandstone dominate the lithology; soils are primarily residual cherty clay soils derived from weathering of dolomite bedrock	Extensive oak savannas and woodlands on sterile acidic upland soils, with pine-oak woodlands associated with sandstone influence
15-Illinois Ozarks	Dissected blufflands and associated alluvial features along the Mississippi River	Ordovician and Mississippian aged limestones and cherty limestones; also Pennsylvanian aged sandstone in central part; soils mostly derived from deep loess	Oak and oak-pine woodlands, with extensive limestone glade and bluff features; local occurrences of mesophytic woodlands and wetlands
13-Inner Ozark Border	Narrow region of moderately dissected plains and hills with localized highly dissected areas associated with major drainages	Primarily Ordovician cherty dolomites, with some Pennsylvanian sandstones and shales; soils are primarily residual weathering products with abundant clay and chert, with some areas of significant loess accumulation	Acid upland timber complex ranging from open oak savannas with a prominent prairie understory on broader flat uplands to dense forests in protected, highly dissected, narrow ravines; and small scattered glades
14-Outer Ozark Border	Narrow region of rugged hills, ravines, and bluffs bordering the Missouri and Mississippi rivers	Ordovician dolomites and sandstones in lower topographic positions, overtopped by Mississippian limestones; soils highly variable, some with a deep and prominent loess component	Oak woodlands in acidic upland soils, with more open oak savannas on the broader uplands and some oak and mesophytic forest in highly dissected areas; small glades
10-Meramec River Hills	Highly dissected, steeply sloping lands associated with Meramec River basin, with narrow ridges and valleys	Both Ordovician and Cambrian dolomite, as well as some expanses of Ordovician sandstone; soils are primarily clayey residuum with abundant chert, and produced as weathering products of dolomite	Oak woodlands with smaller areas of oak-pine woodland and some well developed forests in the deeper valleys and bottoms, with open oak savanna on the broader, sterile uplands

Subsection	Topography	Substrate	Characteristic Ecological System
18-Mississippi River Alluvial Plain	Quasi-stabilized, flat, alluvial plain associated with the Mississippi River channel	Bedrock is deeply buried except for small localized shale and limestone exposures; soils are all alluvial sediments, and mostly with high clay or silt components	Extensive open riparian woodlands with trees such as bur oak and kingnut hickory, with large riparian prairies, marshy sloughs, shrubby wetlands, and limited denser forest areas; seral communities less extensive than on the more dynamic and sediment-laden Missouri River channel
17-Missouri River Alluvial Plain	Flat, low, formerly highly dynamic alluvial plain associated with the Missouri River; formerly prone to frequent flooding, channel migration, and scouring	Bedrock well below surface, with soils comprised of glacial and post-glacial alluvium; soils are typically sandy along active channel runs, clayey in protected sloughs and backwaters, and silty on slightly elevated rises	Complex association of dynamically interphasing riparian communities, ranging from open sand and mud bars to marshy sloughs, shrub thickets and riparian and bottomland forests, typically dominated by seral tree species such as willow, cottonwood, elm, hackberry, and silver maple
8-Osage River Hills	Dissected hilly landscape associated with the Osage River system and its primary tributaries, with both broad uplands and narrow, highly dissected terrain	Thick-bedded, cherty Ordovician dolomites, with significant Ordovician sandstone exposures and limited amounts of limestone, shale, and Pennsylvanian sandstone; soils variable, but often deep and loamy or clayey, with abundant chert residuum	A complex mosaic of open oak woodland and savanna, with tallgrass prairie and limited areas of denser, more mesophytic woodlands in deeper valleys; dolomite glades and bluffs common along major stream dissections.
16-Prairie Ozark Border	Flat to gently undulating upland plain with occasional moderate dissection associated with small streams	Ordovician dolomite and Mississippian limestones, mostly mantled by generally deep soils with prominent clay and rock fragment components	Extensive rolling tallgrass prairies on acidic upland soils, with limited amounts of open oak savannas and oak woodlands in more dissected areas
2-Springfield Plain	Gently undulating plain with generally low relief	Extensive Mississippian aged Burlington Limestone, with abundant chert; soils are primarily cherty silt loams and loams, with a loess component; there are localized areas of clay fragipan soils.	Extensive tallgrass prairie areas, in the higher flat regions, with open savannas and oak woodlands, some on high-base substrates, in dissected terrain, and embedded small limestone glades; small phreatic features in stream valleys

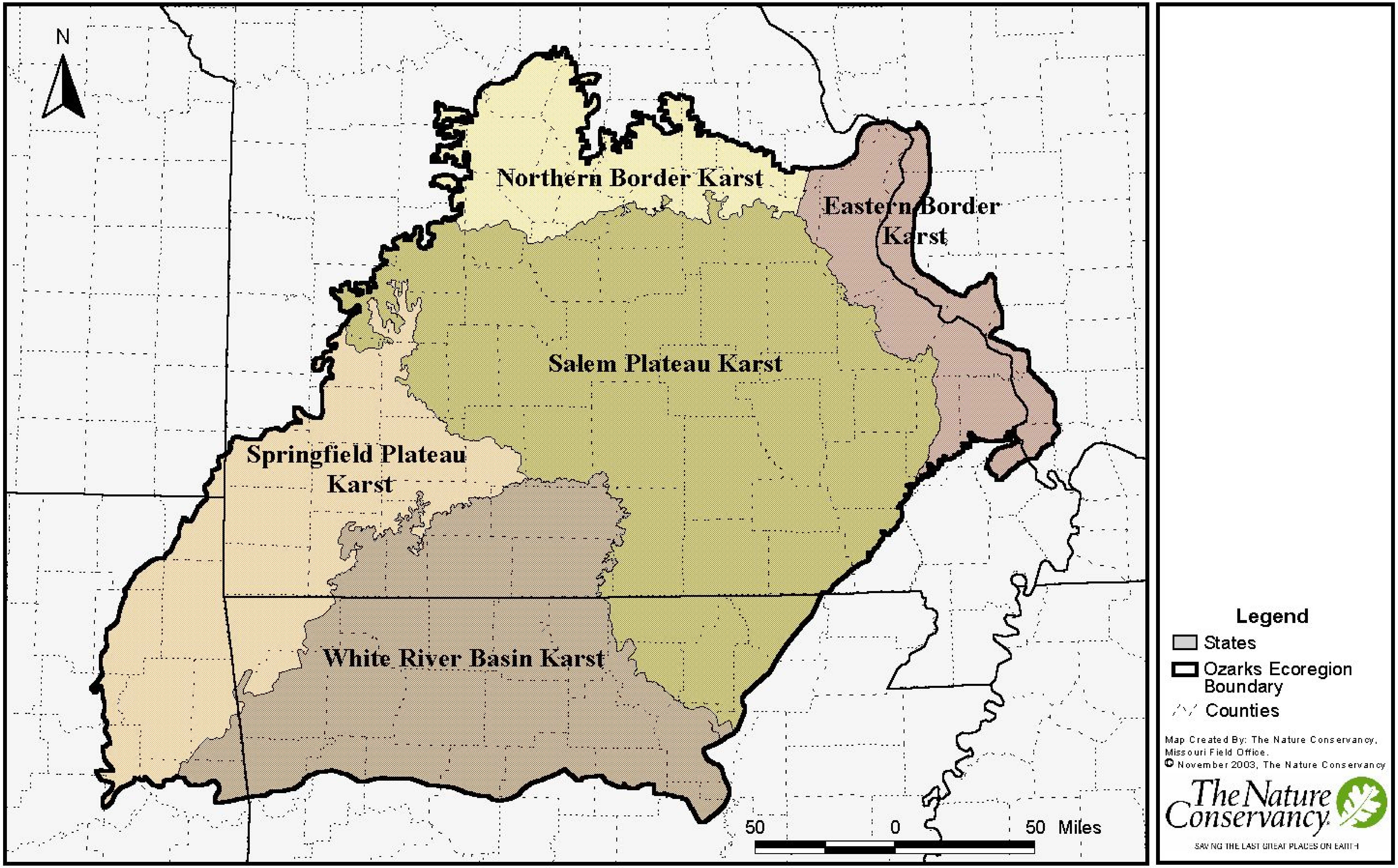
Subsection	Topography	Substrate	Characteristic Ecological System
1-Springfield Plateau	Moderately dissected landscape with localized ridges and steep slopes,	Extensive Ordovician aged Mississippian limestones with localized sandstone and abundant chert residuum	Open oak savanna and woodlands on acidic uplands, with significant tallgrass prairie inclusions
12-St. Francis Knobs and Basins	Distinctive, smoothly rounded knobs and broad intervening valleys, with some areas of rugged, highly dissected terrain and local relief ranging up to 1,000 feet	Ancient, erosionally exposed igneous knobs of complex rhyolites, granites, and associated rocks, with intervening regions of Cambrian dolomites and sandstones; soils on igneous sites are sterile, acidic, and extremely rocky, while soils on sedimentary bedrock are typically weathering products of silty clay loam types, with higher base availability	Oak and oak-pine woodlands and savannas with associated igneous talus slope, glade, and xeric woodland communities on steep-sided, ancient igneous knobs
3-White River Hills	Deeply dissected basin with extensive bedrock exposures and high relief, steep slopes	Dominated by thick-bedded, shaley and cherty Ordovician dolomites, with localized areas of other Ordovician dolomites and sandstones; high base clayey or loamy soils derived from dolomite, and some weathered, acidic soils on uplands.	1) Extensive dolomite glades and glade/high-base woodland complexes, with stranded mesophytic woodlands and stream features in bottomlands and acid deciduous woodlands on cherty ridges; 2) Pine oak, oak-pine, and acid deciduous woodland complexes on sandstone-derived substrates

Karst Subsections

Karst features are moderately developed across the ecoregion with greater development associated with Cambrian dolomites and Mississippian limestones and their areas of outcrop. Subterranean aquatic karst passages are typically better expressed than emergent cave passages. This is reflected in the regional karst fauna, with subsurface aquatic diversity being greater than subsurface terrestrial diversity — a total of 46 stygobite (obligate cave aquatic) species verses 31 troglobite (obligate cave terrestrial) species (Culver, et al. 2003). Endemic species are sometimes restricted to individual cave or spring systems or more commonly restricted to small karst areas or subsections.

Distributional patterns of karst fauna are related more to subsurface bedrock and aquifer patterns than to surface topography. As shown in Figure 3, five distinct karst subsections occur within the ecoregion. These karst subsections are not directly correlated with terrestrial subsections. Each karst subsection is physically distinct and hosts its own endemic species. The Springfield karst subsection is an area of significant aquatic karst systems in limestone, and includes endemic species such as the Ozark Blind Cavefish (*Amblyopsis rosae*). The White River karst subsection is a dissected region of small cave and spring systems in dolomite, and includes endemic species such as the Tumbling Creek Cave Snail (*Antrobia culveri*). The Salem Plateau karst subsection is a dissected region of dolomite that spans major watersheds of the northeastern Ozarks and includes endemic species such as the Salem Cave Crayfish (*Cambarus hubrichti*). The Northern Border karst subsection includes areas of limestone sinkhole and cavern systems, and hosts endemic species such as the Pink Planarian (*Macrocotyla glandulosa*). The Eastern Border karst subsection is a karst sinkhole and cavern area that has been split by the Mississippi River. On the Missouri side of the river is the Perryville Karst Plain, host to endemic species such as the Stygian Cave Snail (*Amnicola stygius*). On the Illinois side of the river is the Renault Karst Plain, host to the endemic Illinois Cave Amphipod (*Gammarus acherondytes*).

Figure 3. Ozarks Ecoregion Karst Subsections

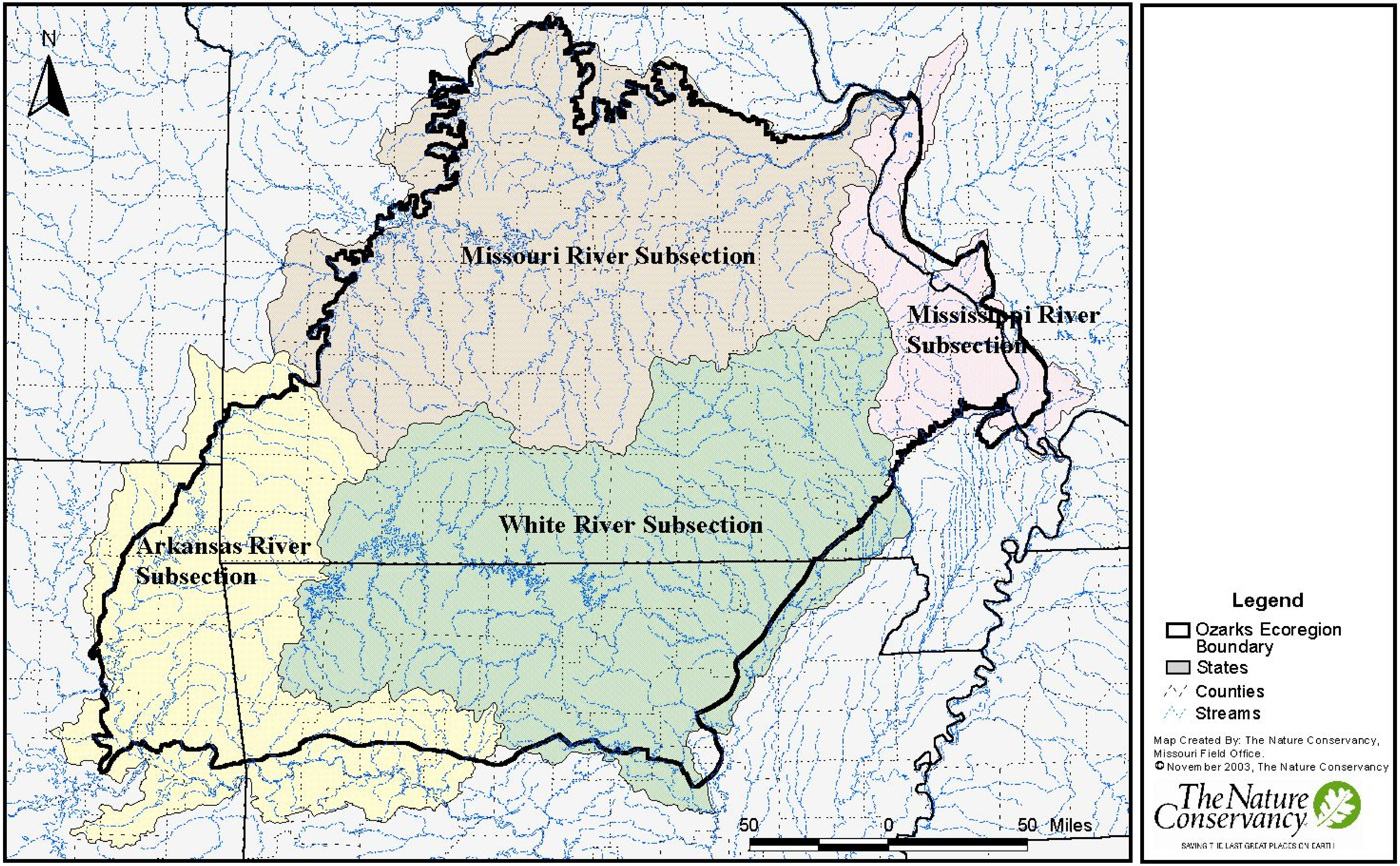


Aquatic subsections

Because of the slow geologic uplift of the Ozark region over the past 100 million years, the landscape is deeply dissected by clear-flowing, often spring-fed, moderate- to high-gradient streams. As with the karst systems, Ozark aquatic systems contain species found nowhere else on earth. Some of the largest freshwater springs in North America occur in the region, as well as more than 9,000 documented caves and thousands of sinkholes. A broad central ridge with elevations generally above 470 meters (1300 feet) runs east-west through the Missouri Ozarks, sloping more steeply to the south than to the north and influencing stream characteristics accordingly.

Aquatic systems of this highland area are bounded by large river systems and alluvial plains, with the Mississippi River on the east, the Missouri River on the north, and the Arkansas River on the south and west. Great age and geographic isolation have led to a high level of endemic aquatic speciesin the Ozarks, particularly fish, crayfish and mussels. Much of this endemism is associated with subterranean karst systems, springs, and clear-flowing, spring-fed streams. Many endemic species are restricted to individual drainage basins. Larger scale biogeographic patterns follow larger basin drainage patterns, with high levels of similarity among the aquatic biota of each aquatic subsection. The White River aquatic subsection contains streams flowing principally southeastward, and includes the endemic Ozark Shiner (*Notropis ozarcanus*) and Ozark Crayfish (*Orconectes ozarkae)*. The Arkansas River aquatic subsection is comprised of streams flowing principally southwestward, and includes the endemic Neosho Madtom (*Noturus placidus*) and Neosho Mucket (*Lampsilis rafinesqueana*). The Missouri River aquatic subsection streams principally flow northeastward, and include the endemic Niangua Darter (*Etheostoma nianguae*) and Britt's Mussel (*Lampsilis reeviana brittsi*). Streams of the Mississippi River aquatic subsection flow principally eastward, and feed directly into the Mississippi River. This subsection includes the Grotto Sculpin, a recently discovered endemic fish closely related to the Banded Sculpin and so not included here as a target. Many of the fish characteristic of this subsection are not included in this report as targets because they are wide ranging and common east of the Ozarks. These aquatic subsections are shown in Figure 4.

Figure 4. Ozarks Ecoregion Aquatic Subsections



4. CONSERVATION TARGETS

To develop an assessment that delineates the globally significant and irreplaceable ecological and biotic features within an ecoregion, one of the first steps is to develop an enumeration of the conservation targets. This is a list of the species, natural communities and ecological systems whose occurrence in the ecoregion is of global significance from a biodiversity conservation perspective. This multifaceted approach to conservation planning - species, natural communities, and ecological systems – is doubly effective. By ensuring sustainable conservation of the full array of functional natural communities and ecological systems that occur in the ecoregion, it facilitates the efficient conservation of species which are demonstrably of global conservation concern. At the same time this approach facilitates conservation of the much larger group of organisms for which there are little or no data available for conservation planners. This mechanism of imputing sustainable conservation of poorly known or unknown organismal targets through sustainable conservation of the full spectrum of autochthonous natural communities is often referred to as the coarse filter approach.

The key goal of ecoregional conservation from the Conservancy's perspective is the conservation of multiple examples of all elements of the autochthonous biota in sustainable, interactive arrays. Theoretically, this could be accomplished by conserving functional examples of all natural communities that occur in the ecoregion, since all of the biota in the ecoregion are associated with at least one natural community. In practice, additional focus on individual species in several categories is necessary to buffer against uncertainties in our knowledge of natural communities, and for conceptual clarity, efficient deployment of resources, and ensuring the continued presence within the ecoregion of certain highly vulnerable species. The following account of how conservation targets for the ecoregion were derived and enumerated is divided into separate sections for species, natural communities, and ecological systems.

For the Ozarks ecoregion, the bordering portions of the major rivers — the Arkansas, Missouri and Mississippi rivers — and their associated aquatic species were excluded. These large river systems are essentially peripheral to the ecoregion and function on spatial and process regime scales that transcend individual terrestrial ecoregions, making piecemeal attempts at conservation planning counterproductive. Conservation planning and implementation for these large rivers is best accomplished through assessments such as The Nature Conservancy's Upper Mississippi River Project (Weitzell, et al. 2003). Four target fish species restricted to the mainstem channel communities of these big rivers are excluded from this assessment: Pallid Sturgeon (*Scaphirhynchus albus*), Bluehead Shiner (*Pteronotropsis hubbsii*), Sicklefin Chub (*Hybopsis meeki*), and Sturgeon Chub (*Hybopsis gelida*). Additionally, two other fish included in this assessment occur in the lower reaches of Ozark rivers such as the Osage and Gasconade rivers, but the majority of the local populations occur in the big rivers and is not captured in this assessment. These species are the Western Sand Darter (*Ammocrypta clara*) and the Lake Sturgeon (*Acipenser fulvescens*).

<u>Species Targets</u>
Five general categories of species, referred to as target classes, were identified as ecoregional conservation targets based on their distribution, conservation status, and performance in the contemporary landscape: 1) endemic species; 2) modal species; 3) globally rare species; 4) declining species; 5) highly disjunct species. These categories were developed and populated through synthesis of a diverse cohort of sources, including Natural Heritage Program data, published literature reports, online databases, unpublished field data, and expert opinion. Although data quality and quantity vary widely among different organismal groups, and sometimes among different states for the same organismal group, attempts were made to determine species targets from the broadest possible spectrum of Ozark biota. Still, this list does not capture all target species in the ecoregion. Numerous examples of Ozark biota are currently undescribed or too little is known regarding their potential conservation significance or geographic distribution to be included as species targets at this point. For example, Harris and Ladd (2003) enumerate more than 50 undescribed species of lichens in the Ozarks ecoregion. Future iterations of the Ozarks Ecoregional Assessment should continue to

refine the list across all organismal groups. A total of 407 species were identified as species targets in the Ozarks ecoregion.

To streamline the selection process, species targets were selected hierarchically by target class according to the sequence enumerated below; that is, all endemic species (#1 below) were selected first, and the remaining biota of the Ozarks were screened for modality (#2 below) within the ecoregion. After selecting modal species, the remaining biota were then screened for globally rare taxa (#3 below) and so on. Thus, the category of globally rare species targets actually represents the non-endemic, non-modal taxa occurring in the Ozarks that are globally rare, and not the full array of globally rare species in the ecoregion.

Brief descriptions and examples of the target classes used in the Ozarks are as follows:
1. Endemic species — These are species whose entire global range is restricted to the Ozarks ecoregion. Because such organisms occur nowhere else on Earth, they must become conservation targets in the Ozarks to ensure their continued existence. In practice, a few species that are essentially endemic to the Ozarks ecoregion, but with a single outlier population outside of the ecoregion, are considered to be endemics for the purposes of this assessment. For example, the Ozark Crocus (*Tradescantia longipes*) a common spring wildflower restricted to the Ozarks except for an outlier population in the Ouachita Mountain region to the south, is considered an endemic species in this assessment. Of the 407 total species targets identified within the Ozarks ecoregion, 159 (39%) are classified as endemic. This further reinforces the importance of the Ozarks as a New World temperate center of endemism. Note that not all endemic species are rare — for instance Bush's Skullcap (*Scutellaria bushii*), an attractive blue-flowered mint, is common on dolomite glades in the eastern Ozarks of Missouri and Arkansas. The power of ecoregional conservation assessment is that such taxa are identified and documented as globally significant in advance of critical threats to species survival, allowing more efficient and effective proactive conservation planning and implementation.

2. Modal species — Another class of species targets encompasses organisms which may have broad geographic ranges, but for which a majority of the total global population occurs within the Ozarks. For example, the vast majority of the world's population of Banded Sculpin (*Cottus carolinae*), a small fish associated with spring-fed systems, occurs within the Ozarks, even though the species is distributed in other ecoregions in the central United States. For migratory animals, this category includes taxa for which a majority of the global populations utilizes the Ozarks at some point in their life cycle beyond mere transience through the ecoregion, and includes both species that inhabit the Ozarks during breeding season and species that winter in the Ozarks. Seventy-seven (19%) of the 407 species targets in the Ozarks are classified as modal species.

3. Globally rare species — Globally rare species are perhaps the most intuitive target class. These are taxa manifestly in need of explicit conservation attention for their continued existence. For this assessment, global rarity is defined as those species with assigned Global Ranks (G-Ranks) of G1-G3. Global ranks are a simple ranking of a target's relative imperilment and conservation status across its entire range, and are expressed on a scale from G1 (critically imperiled) to G5 (secure). Thus, the California Condor (*Gymnogyps californianus*) is G1 and Common Ragweed (*Ambrosia artemisiifolia*) is G5.

There are two distinct patterns of global rarity: 1) habitat or process limited taxa that were always rare in the post-glacial environment, and 2) formerly more abundant species that have declined as a direct consequence of anthropogenic perturbations associated with the post Euro-settlement environment. The process of identifying these two categories of rare species as conservation priorities is analogous. For all species, provisional ranks were defaulted to the higher priority G-rank: a species ranked G3G4 was considered to be G3 in developing the target list. For species lacking an assigned G rank, as is the case with many cryptic or poorly known organisms, an inferred G-rank was provided if sufficient data were available. Thus, although not assigned a G rank or tracked by NatureServe or local State Natural Heritage programs, the Hellbender Leech (*Batracobdella cryptobranchii*) is obviously a globally rare species, since it is an obligate parasite of the globally rare Ozark Hellbender (*Cryptobranchus alleghiensis bishopi*). Similarly, although not tracked or ranked, the lichen *Pyrenula michneri* is a globally rare conservation target. Formerly thought to be extinct (Harris 1989), and last documented alive in 1893 in Ontario, Canada, this lichen is currently known in the entire world only from a single recently discovered site along the Eleven Point River in the Missouri Ozarks. Eighty-one (20%) of the 407 species targets in the Ozarks are classified as globally rare taxa. Because of the hierarchical nature of the target derivation, and the fact that many endemic and modal species targets are also globally rare, the actual number of taxa in the Ozarks with priority G-ranks (G1, G2 or G3) is actually significantly higher (51%), as shown in the accompanying chart.

Global Rank Distribution of Target Taxa in the Ozarks Ecoregion

G-rank	Number of Taxa	Percent of Total Target Taxa
?	32	7.9
1	46	11.3
2	53	13.0
3	109	26.8
4	70	17.2
5	97	23.8
Total	**407**	**100**

4. Declining species — Regardless of their current status or global distribution, species that are currently experiencing significant range-wide declines are included as conservation targets. As used in this assessment, significant decline is defined as an estimated or inferred global population reduction of 40% or more in the last two centuries, with no evidence of sustainable population rebound in the past two decades. As a practical matter, for all of the Ozark species in this category, these declines are the direct result of post Euro-settlement anthropogenic patterns. An example of a declining species is the Cerulean Warbler (*Dendroica cerulea*) which is experiencing significant population decline throughout its range. Thirty-two (8%) of the 407 Ozark species targets are considered to be declining species.

5. Highly disjunct species — A distinct cohort of Ozark biota consists of taxa which have broad geographic distributions in regions remote from midcontinental North America, but for which the Ozark populations represent outliers typically several hundred miles disjunct from the main range of the species. There are compelling arguments from conservation biology and genetic perspectives for the conservation of peripheral and disjunct populations, which often have higher aggregate heterozygosity and contain a disproportionate amount of total genetic diversity for the species. Many of the highly disjunct species in the Ozarks are relictual species from the Wisconsonian glacial period, when the Ozarks served as a refugium for biota displaced from further north. During the past 15,000 years, as the glaciers receded and the climate and environment of the Ozarks became similar to that of today, some of the species present in the Ozarks during the glacial period managed to survive in suitable microhabitats, and are today far removed from the nearest occurrences of the same species far to the north, such as the Four-toed Salamander (*Hemidactylium scutatum*). Another cohort of disjunct species includes taxa with biogeographic affinities to the southwestern region, such as Ashe Juniper (*Juniperus ashei*); these taxa are presumably relictual from the post-glacial xerothermic period when the climate was warmer and significantly drier, much like the environment in our modern southwestern deserts. A third class of disjunct species are organisms associated with a moist, warm environment associated with the modern Gulf Coastal Plain. Fifty-eight (14%) of the 407 total species targets in the Ozarks are classified as highly disjunct species.

For this assessment, species targets are further classified based on conservation status, the system they occur in, and their habitat preference described as follows:

1. Primary/secondary species targets — Primary targets are used for initial portfolio selection, and consist of species classified as endemic, modal, and the rarest subset of globally rare species (those ranked G1 or G2). Secondary targets are used for assessing portfolio completeness, and consist of species classified as declining, highly disjunct, and globally rare species ranked G3. Note that incomplete occurrence data precludes determination of target capture for many secondary species or their incorporation in the portfolio design process.

2. System classes — Each target species is then assigned to one of three system classes based on its pattern of occurrence in the Ozarks: terrestrial, aquatic, or karst. Karst species are those obligately associated with caves, springs, and phreatic features, and include both aquatic (e.g. cavefish) and terrestrial (e.g. bats) organisms. Aquatic species are obligately associated with surface aquatic habitats, including stream and river systems, ponds, sloughs and other aquatic environments. Terrestrial species are associated with surface natural communities including wetlands, and include both aquatic and terrestrial organisms. Each species is thus linked to the appropriate natural system type (surface aquatic, subterranean terrestrial and aquatic, and terrestrial with wetland), without regard to the myriad possible physiognomic and taxonomic attributes for the taxon.

3. General habitat class — Each target species is also assigned a general habitat class following a similar systems based approach. Karst system species were either Cave (CV) if emergent or Aquatic Cave (AQC) if associated with subterranean waters. Troglophiles such as bat species were assigned to "Cave" (CV) habitat for assessment purposes. Surface aquatic system species were assigned to a general category (AQ) if data was lacking or one of four other distributions as appropriate: habitat generalists (AQG) for those found from headwaters to large rivers, headwater species (AQH) for those found in a variety of habitats from headwaters to small rivers, river species (AQR) for those found from small to large rivers, and spring species (AQS) for those obligate to springs and spring runs. Terrestrial system species were assigned to the following habitat categories: Bottomland Forest (BF), Bottomland Prairie (BP), Bottomland Savanna and Woodland (BS), Fens and Seeps (FS), Glade (GG), Habitat Generalist (HG), Rock Outcrop (RO), Shrub Habitat (SH), Sinkhole Pond (SP), Upland Mesic Forest (UF), Upland Prairie (UP), Upland Savanna and Woodland (US), and Wetland (WL). Appendix 1 provides an enumeration of all Ozarks ecoregional targets, their habitat classes, and other attributes.

Terrestrial Natural Community Targets

The pattern of biotic assemblages in the landscape reflects a punctuated continuum, with numerous variables influencing composition at a particular locus on the earth's surface. This renders the biota of every acre measurably different from any other acre. Still, repeating patterns and associations in response to environment, history and process regime give rise to describable entities with some consistency of biotic pattern. Since this concept of natural communities is largely a construct of convenience for classification purposes, delineating the number and characteristic of these communities is dependent upon perspective and scale.

In the Ozarks ecoregion, an initial circumscription of communities was derived from a Natural Heritage Program list of Ozark terrestrial natural communities (TNC 1999) augmented by data from Kansas and Illinois. This list included coarse classification of karst and aquatic types as well. The list was then evaluated and crosswalked by the core team and selected ecologists familiar with the natural communities of each state. Additionally, the Missouri portion of the natural community list was evaluated against Nelson (1985) and amended to ensure inclusion of the full diversity of Ozark natural communities.

The resulting list of 102 natural community types was then used in an initial experts meeting, held in the fall of 2000, involving the core team and ecologists from all states except Kansas. At this meeting, each natural community was evaluated for its potential occurrence within each of the nineteen terrestrial subsections of the Ozarks ecoregion. In the course of this process it became evident that several putative community types recognized by Natural Heritage programs were untenable from a conservation planning perspective. This resulted from one of four primary reasons: 1) community classification largely based on current condition rather than sustainable synecologically intact states; 2) microseparation of phases of variable, dynamic communities based on transitory or ephemeral compositional attributes - in practice such systems are inseparable and unmanageable as static entities; 3) a classification system based solely on vegetation is not an adequate means of natural community delineation in many instances; and 4) lack of occurrence data through much of the ecoregion for many narrowly defined community types.

To address these issues, and to create a classification system for natural communities that reflected on-the-ground interrelationships and facilitated applied conservation planning and tracking, the entire subset of natural communities was re-evaluated by a team of ecologists and the core team, with careful consideration of all of the comments and issues raised at the natural community experts meeting. This resulted in recombination of several closely related natural communities into a series of natural community complexes. The resulting classification is more reflective of the variability and occurrence of the communities in the landscape, and facilitates tracking of discrete entities for conservation assessment. As a result of this process, a total of 59 terrestrial natural communities and functional natural community complexes were recognized as occurring in the Ozarks ecoregion (Appendix 1C). This includes communities which occurred within the ecoregion in the recent post-glacial period, even if no examples are currently known to exist.

These 59 terrestrial natural communities are the target universe for terrestrial conservation planning in the Ozarks. In every case where a natural community type occurred within a terrestrial subsection, the pre-Eurosettlement occurrence pattern of that community within the subsection (matrix, large patch, small patch) was also determined. Matrix communities occur in large expanses of typically more than 1,000 acres (400 ha). These communities shape the dynamics of the landscape where they occur, influencing the biological and physical relationships of the embedded smaller community types. Large patch communities typically occur on a scale from 100 (40 ha) to 1,000 acres (400 ha), and are usually embedded within matrix communities. Small patch natural communities are typically limited by discrete physical factors, such as hydrological or bedrock features, and are usually 100 acres or less in extent.

The resulting table provides a baseline of community occurrence and pattern across the ecoregion (Appendix 2). This table of natural community occurrence and pattern by terrestrial subsection across the ecoregion can be used to ensure that the full spectrum of natural community variability within the ecoregion is captured sufficiently to serve as an adequate coarse filter. Natural community pattern is an important consideration in assessing viability, since a community type that originally occurred as a matrix community is probably not viable as a small patch occurrence in a degraded landscape.

<u>Karst Natural Community Targets</u>

Enumeration of karst natural communities from state Natural Heritage programs produced a short list of springs, dry caves and wet caves. Hebrank's (1989) geologic classification system for Ozark caves utilizes physical attributes such as extent, planform and ingress or egress of water. Nelson (1985) has adapted a version of that system that designates five cave types. A similar classification system for springs (Vineyard, 1974) also follows physical attributes such as size class of discharge and subsurface flow regime (vadose, phreatic, or ebb & flow from a siphon). However, neither Heritage Program data or GIS map data were able to reliably distinguish needed attributes to be able to apply these cave or spring classification systems. At best, map data supply name and location information for the two largest size classes of springs and similar information for a very small set of cave features. While speleological databases in the respective states may contain attributes needed for cave classification, they are proprietary in nature and closely held to protect sensitive cave resources from disturbance.

For pragmatic reasons stemming from data limitations, springs have been broadly classified into three community types for the Ozarks: Large Spring, Small Spring, and Saline Spring. Large springs are the first and second order springs (mean discharge > 10 cfs) commonly issuing from the Ozark aquifer of Cambrian and Ordovician age dolomite along mainstems of large and small rivers. Small springs are third through fifth order springs (mean discharge< 10 cfs) issuing typically from shallow and relatively local recharge areas. Small springs are often key features of small creek systems that maintain stable cold water flow throughout the year. Saline spring is a unique spring type restricted to one small area on the north edge of the ecoregion. Here small springs flowing through subsurface marine sediments result in saline discharges. Caves are classified in this assessment as Cave and Aquatic Cave. Cave is a terrestrial cave environment supporting troglobites that are sustained through nutrient inflows and droppings of troglophiles, typically bats and/or crickets. Aquatic caves are subterranean passages wholly or partially filled with water supporting stygobites. Large cave systems will frequently include both of these subterranean environments — a cave system with a surface opening for troglophiles and a cave stream with considerable vadose recharge.

Aquatic Natural Community Targets

The only functional aquatic natural community classification system for the Ozarks at the time of this assessment was Pflieger (1989). This system is roughly based on four size classes defined by miles from basin head, as well as categories of spring runs, sloughs, and sinkhole ponds. More modern classification systems also take into account substrate type, flow regime, temperature regime, and geomorphic characters such as gradient, sinuosity, and floodplain character. However, such systems are complex in the number of permutations of possible characters and challenging to accurately map. Aquatic gap analysis programs designed to meet these challenges were underway in Ozarks at the time of this assessment. Rather than attempt to generate a less sophisticated version of the aquatic gap analysis for this assessment, the Pflieger classification has been used in this assessment. Sinkhole pond environments are captured under terrestrial communities, leaving six functional aquatic communities for the Ozarks: Spring Run, Slough, Headwater Stream, Creek, Small River, and Large River. As explained in the introduction, Big Rivers of the Missouri and Mississippi have been excluded from this assessment and will be treated in separate assessments.

Even though this aquatic classification is coarse, the robust suite of aquatic species targets results in a comprehensive fine filter selection process. A total of 135 species targets (33% of all Ozark species targets) are surface aquatic species. These targets span the full range of aquatic organismal groups, including reptiles, fish, crayfish, mussels, amphipods, isopods, other invertebrate groups, and aquatic plants. As discussed previously, the functional habitat of each aquatic species was determined and coded: obligate spring branch (AQS), headwaters (AQH), rivers (AQR), and habitat generalists (AQG). A rapid informal analysis of habitat pattern representation among target aquatic species reveals that the target species universe is well stratified among the full range of aquatic macrohabitats in the ecoregion. Additionally, the target species are well stratified biogeographically among the three main aquatic faunal subsections of the Ozarks, although represented to a somewhat lesser degree to a somewhat lesser degree in the Mississippi River aquatic subsection. Since this assessment incorporates adequate to excellent occurrence data for a robust suite of aquatic targets through a majority of the region, including species with habitat affinities spanning the full spectrum of Ozarks aquatic habitats, the fine filter selections for aquatic target species results in a comprehensive portfolio encompassing the full array of aquatic community diversity.

Ecological System Targets

Because larger, more biologically and physically complex areas have a greater inherent stability and buffering effect against the inevitable changes that beset all environments, targets are most successfully conserved within intact ecological systems. Ecological systems are defined as:

> *Dynamic spatial assemblages of ecological communities that 1) occur together on the landscape; 2) are tied by similar ecological processes, underlying environmental features or environmental gradients; and 3) form a robust cohesive, and distinguishable unit on the ground. (Groves et al. 2000)*

Within the Ozarks ecoregion, each subsection is characterized by a distinct association of natural community types, patterns, and spatial relationships. This characteristic complex of intermingled, interactive natural communities constitutes a representative ecological system for the subsection. Where feasible on the landscape, conservation of ecological targets within functional ecological systems provides a higher probability of sustainability over time. Characteristic ecological systems for each terrestrial subsection are described Table 1; Nigh and Schroeder (2002) provide more detailed descriptions of terrestrial ecological systems for Missouri terrestrial subsections. Aquatic ecological systems are defined as functional stream networks containing viable and interconnected representations of the full array of stream magnitude from headwaters through mainstem reaches.

5. Conservation Goals

To sustainably conserve the full array of biological diversity within an ecoregion, conservation goals must be sufficiently robust to ensure the continued survival of the target over time and stochastic events. In the case of natural communities, conservation goals must take into account the spatial pattern of variation inherent in each natural community type. In order to ensure efficiency and maximize feasibility, conservation goals must also attempt to predict the minimum numerical thresholds to accomplish this.

Unfortunately, much conjectural but little verifiable information exists regarding the two most compelling questions in conservation biology: how many occurrences and how much area per occurrence are sufficient to ensure sustainable conservation? What little information exists is largely based on untested theoretical models or is based upon organisms or systems for which there is no confidence that the results can reliably be extrapolated to other targets. Thus, conservation planning must rely on expert opinion, a few general tenants (e.g. Groves et al. 2000), and insightful predictive analyses.

The conservation goals derived for the Ozarks ecoregion, developed to ensure target viability over a minimum one hundred-year interval, are enumerated by target type in the following discussion. These goals are based on best available information, and subject to the limitations discussed previously. Future iterations of this assessment will change to reflect better predictive tools that are being developed in conservation biology.

<u>Goals for Terrestrial, Aquatic, and Karst Species Targets</u>
In general, a default minimum conservation goal for species is to conserve two viable populations of species targets in each ecoregion or ecoregional section where they occur, with a minimum of ten conserved populations across the global range of the species. A variation of this was used in deriving species conservation goals in the Ozarks ecoregion.

For every primary species target (endemic, modal, and G1-G2 species), the goal was to capture in the aggregate ecoregional portfolio a total of ten occurrences within the ecoregion or all viable populations for taxa known from less than 10 sites. For planning purposes, each discernable interactive aggregation of metapopulations was deemed a single occurrence. For aquatic species, each eight-digit watershed (HUC8[1]) where the species was present, even if represented by multiple populations, was treated as a single occurrence. For the lowest priority subset of globally rare target species (those ranked G3), the goal was to conserve a minimum of two viable occurrences within the ecoregion, since by definition according to the hierarchical stratification of Ozark targets, all of these species should be better represented in other ecoregions.

No conservation goals were developed for other secondary species targets (declining and highly disjunct species), since in practice more than 50% of these taxa have insufficient, inconsistent or uncertain occurrence and viability data. Those groups for which sufficient data exists were used to crudely test completeness of capture in the portfolio selection practice, and these data indicate that tracked secondary targets were sufficiently captured to meet the goals derived for primary targets.

<u>Goals for Terrestrial Natural Communities</u>
Some ecoregional assessments (e.g. TNC 2000b) have attempted to incorporate consideration of range-wide distribution patterns for natural communities into the development of conservation goals. However, the inherent uncertainty of our understanding of the complexity, composition and intraspecific variation

[1] Hydrologic unit code — a national classification to uniquely identify watersheds within a hierarchical spatial grouping of waterways. The eight digits are comprised of a series of four hierarchical two digit codes designating the region the watershed is in, followed by the sub-region, the accounting unit, and the cataloging unit or watershed.

within supposedly identical community types across geographic ranges calls into question this concept. For example, considering a tallgrass prairie in the Ozarks to be analogous to the natural community of the same name in the western Flint Hills seems inappropriate, despite the facts that they both have coarse structural similarities and linguistic limitations force the two to be squeezed into the same restrictive nomenclatural concept. From a floristic similarity perspective, the Ozark prairie is demonstrably more closely related to other Ozark community types, such as savanna, even though it may appear less similar from a gross structural perspective.

Because of this, the Ozarks ecoregional assessment does not attempt to stratify terrestrial natural community conservation goals according to supposed pattern of occurrence of a particular community type beyond the ecoregion. In essence, we are treating all communities as endemic, in order to ensure that the full range of natural community variability is captured, to provide a true coarse filter for poorly understood organismal groups (which are an overwhelming majority of the components of any natural community), and to buffer against the monumental gaps in our understanding of community variation and dynamics. For perspective, information about the imputed global range and rankings of terrestrial natural communities is included in Appendix 1B.

Conservation goals for terrestrial natural communities were established according to the pattern of community occurrence in the pre-Eurosettlement landscape. For matrix communities, the conservation goal is one viable occurrence in every terrestrial subsection where that community occurred as a matrix system, with a default goal of three conserved viable occurrences regardless of subsectional distribution pattern.

For both large patch and small patch terrestrial natural communities, ecoregional goals are to conserve ten viable examples stratified as broadly as possible across the ecoregion commensurate with embedment in viable matrix communities or matrix community complexes. A second phase of this goal was to include for each community type the five highest quality occurrences in the ecoregion regardless of geographic stratification.

<u>Goals for Aquatic Natural Communities</u>

As discussed previously, most of the aquatic portfolio was derived by using a fine filter selection of constellations of most viable aquatic target species occurrences. To ensure some level of coarse filter selection, the resulting design was tested for broad aquatic community capture in each of the four aquatic subsections. The default conservation goal in each aquatic subsection was to capture viable examples of each coarse community type in three different watersheds in each aquatic subsection. Aquatic biologists and regional fisheries experts were consulted to fill the few resulting gaps that were not selected through the fine filter approach. These sources identified the best quality examples with an emphasis on connectivity to previously selected reaches.

<u>Goals for Karst Targets</u>

As with aquatic systems, selection of conservation priorities was driven primarily through a fine filter selection for species targets. Given the difficulties in obtaining functional karst community data, a surrogate coarse filter selection process was devised. The five best karst areas, defined as the most target-rich from Natural Heritage Program and other karst data sets, were selected in each of the five karst subsections. In practice, there was insufficient cave data to reliably accomplish this in the Northern Border karst subsection. Additionally, all Priority 1 sites for Federally Listed species were automatically included as sites. These were principally bat caves but also included some cave crayfish sites.

Goals for Ecological Systems

Conservation goals for ecological systems were driven by landscape patterns and the need for geographic representation. For each terrestrial subsection within the Ozarks, the goal was to conserve one viable ecological system containing an interactive representation of the principal matrix communities and their associated smaller communities and biota characteristic of that terrestrial subsection. Similarly, an ecoregional goal was to conserve one viable aquatic ecological system connected from headwaters to large river within each of the four aquatic subsections in the ecoregion. Finally, conserving one multi-site karst area within each of the five karst subsections was established as a default goal for karst systems, in light of the overwhelming lack of system-level data for karst habitats.

6. Viability Assessment

A critical factor for ensuring sustainable conservation of biodiversity is the determination of which occurrences of conservation targets are viable. Viable occurrences are those that have a high probability of retaining their conservation targets over time (typically imputed to be a minimum 100 year interval). Obviously, resources expended on conservation targets that are not viable wastes resources and diverts time and conservation attention from potentially viable target occurrences.

As with conservation goals, viability assessment as a disciplined, tested science is virtually nonexistent for most targets. Consequently, viability determinations are based in large measure on theoretical concepts, best available information, and expert opinion. In this assessment, initial viability determinations for natural communities and ecological systems are configured as a yes/no filter, establishing minimum criteria for viability for each target class. Thus, for natural communities and ecological systems, a target occurrence is either viable and has the capability of being sustained over time, or is not viable, with no assurance of being sustainable over time despite management and restoration efforts.

Viability determinations as used in this assessment are a synthesis of three conceptual components: size, condition, and landscape context, as shown below for terrestrial natural community targets.

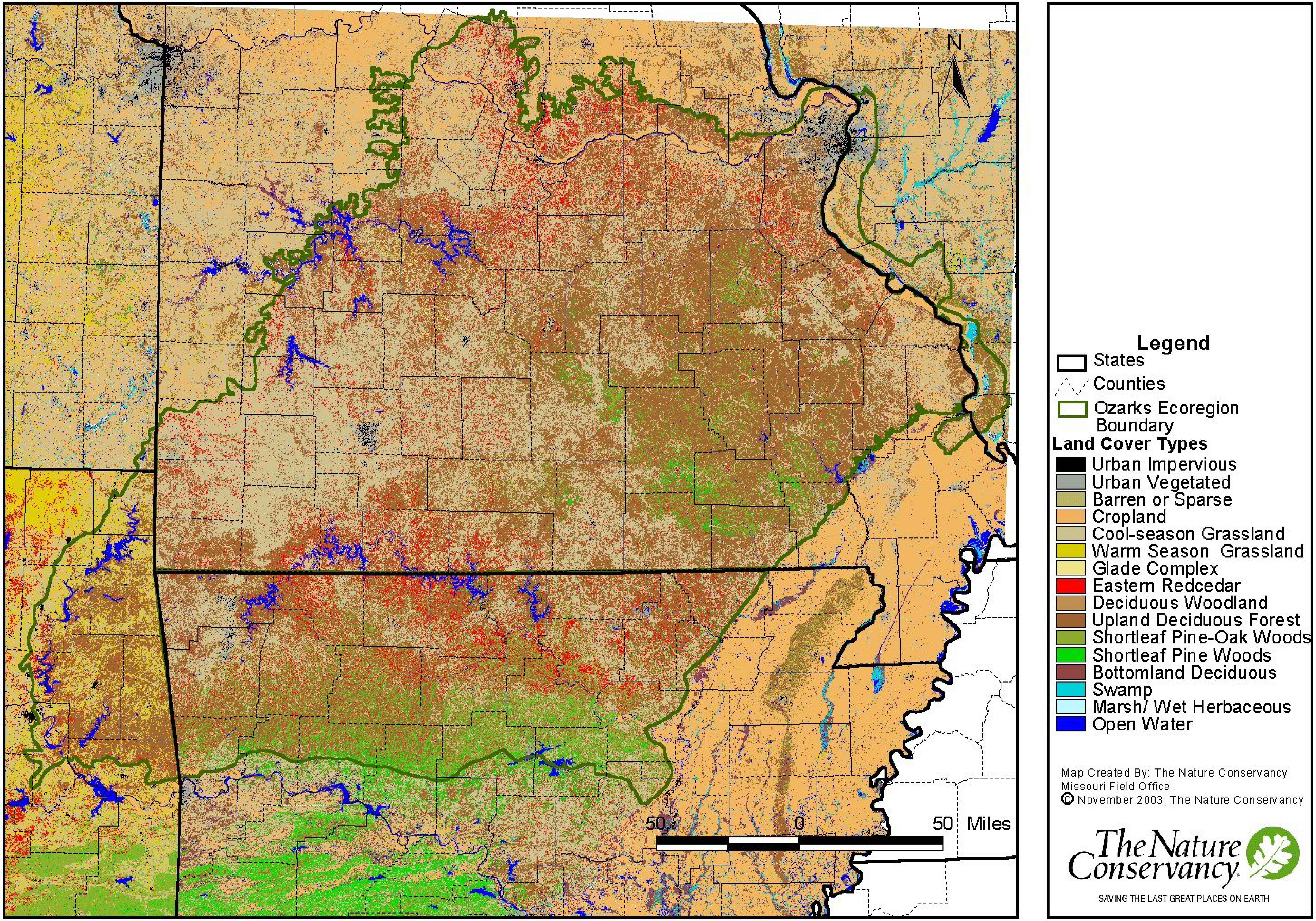
Community Pattern	**Minimum Criteria For Viability**		
	Size	**Condition**	**Landscape Context**[1]
Matrix	> 400 ha (1,000 ac)	EO rank[2] > D, or >80% native cover	>50% native cover in surrounding landscape buffered to 200% of EO size
Large patch	> 40 ha (100 ac)	EO rank (or imputed EO rank) > D	Embedded in viable matrix, or >25% native cover, or >50% structurally similar to native cover
Small patch	100% of original occurrence	EO rank (or imputed EO rank) > D	Embedded in viable matrix, or >25% native cover, or >50% structurally similar to native cover

[1]Current land cover for the ecoregion is shown in Figure 5.
[2]EO rank = element occurrence rank, a relative ranking of the quantity of the target, and ranges from A-D.

In practice, viability considerations are suffused with pragmatic considerations of feasibility and relative ecological health, resulting in a range of relative viability ranks for the occurrences of a given target. These rankings can be useful tools in making decisions about where to deploy conservation resources.

For species targets, viability was often defaulted to the Natural Heritage Program element occurrence rank (EO rank), modified as necessary by expert opinion. For the numerous occurrences without valid EO ranks, expert opinion was used to assign a surrogate viability rank. Unless there was explicit evidence to the contrary, occurrences within viable ecological systems were axiomatically considered to be viable. For karst species occurrences without Heritage rankings, occurrences designated by experts within the last 20 years as “good” and occurrences within karst features containing occurrence records of similar species with viable Heritage ranks, are considered viable.

Figure 5. Ozarks Ecoregion Current Land Cover



State Natural Heritage Program tracking data for many target aquatic species was inconsistent. Ecoregionally important species with multi-state distributions are often tracked in one state where the species is less common but not tracked in the state or states containing the main range for the species. To overcome this phenomenon, a database was compiled for the occurrences of all aquatic target species by eight-digit hydrologic unit (HUC8) within the ecoregion. Data were assembled from Heritage data sets, the Missouri Aquatic Gap project, the Ozark-Ouachita Highlands Assessment data (USDA Forest Service 1999), and personal communications from Conservancy staff and other biologists in the ecoregion. Each record of this HUC8 aquatic occurrence table was populated with four components for viability ranking.

These four components of aquatic target viability rankings are: 1) size, as indicated by population size; 2) condition, as reflected by Environmental Protection Agency watershed ratings (USEPA 2002); and landscape context, as reflected by both 3) percent native land cover in the watershed and 4) absence of mainstem reservoirs. Details of how these criteria were derived and applied for each of the criteria are explained below.

1. Size - Population rank is a relative ranking system based on collection data for common species and Heritage rankings for rarer taxa. The default ranking for data from recent collections or expert observations when more detailed abundance data is lacking is "B" rank. An "A" rank is the largest population occurrence(s) for rare species or a species that is clearly abundant. A rank of "B" is the default rank for less abundant occurrences. A rank of "C" is for species that have clearly a less common distribution in the watershed than other areas, or that have been declining in recent years as shown by Heritage or collections data. A "D" rank is the lowest abundance ranking, often derived from spurious data or questionable identifications. A rank of "I" is reserved for those occurrences known to be from introductions either by accident from inter-basin transfer of bait species by fishermen, or purposeful introductions for sport fishery management.

2. Condition - EPA watershed ratings are a composite index of watershed indicators that relate to overall water quality in an eight-digit hydrologic unit. These indices synthesize state water quality inventory data and other indicators of public health and environmental concern, and assign one of six categories to the watershed, ranging from "Better water quality" (low vulnerability) to "Water quality problems" (high vulnerability). Because some Ozark watersheds lack sufficient data for the complete EPA classifications, USGS water quality data were used to correlate data from non-EPA ranked basins to adjacent basins with EPA rankings. These rankings are expressed as one of four categories ranging from "very good" to "bad", and are shown in Figure 6A.

3. Native land cover - Land Use Land Cover (LULC) Rank was calculated from GIS grid coverage for the ecoregion from late 1990's satellite data assembled for various state Gap Analysis projects. The sixteen vegetation classes were reduced to native and non-native cover and percent cover of native then calculated for each HUC8. Classifying using a natural break-point statistical segregation yielded four ranks: Very Good = 69-94%, Good = 55-69%, Moderate = 42-55%, Bad = 28-42%. These rankings are shown in Figure 6B.

4. Mainstem reservoirs - Mainstem rankings were based on two factors, the presence or absence of mainstem dams and reservoirs and the number of miles of undammed mainstem river. Miles of mainstem were calculated from EPA stream reach files [RF1], based on a river beginning 30 miles from the head of the stream and ending at the base of the hydrologic unit. All miles of mainstem under impoundment were excluded from the measure, and a buffer of 20 miles below any mainstem dam was excluded from the measure. Rankings were applied as follows: Very Good = greater than 30 miles of mainstem with no dams or reservoirs, Good = greater than 30 miles of mainstem with dam(s) altering flow or fish migration, Moderate = less than 30 miles of mainstem with no dams, Bad = less than 30 miles of mainstem with dam(s). These rankings can be seen in Figure 6C.

These four rankings can be combined for each HUC8 occurrence record to give a relative viability ranking for the watershed. From these rankings, best watershed occurrences can be selected for any target species. In most cases for primary targets, these would represent the best known global occurrences for the target. Cross tabulations can then reveal the number of highest ranking occurrences for each HUC8 in the ecoregion, which serves as a rough indicator of conservation priority. Table 2 shows the distribution of the number of highest ranked species occurrences for Ozark watersheds. Note that the Buffalo and Current rivers each contain the world's best populations for a significant number of target aquatic species, together accounting for the best occurrences for 34 aquatic taxa.

Table 2. Aquatic Site Target and Best Occurrence Tally

Site Number	Name	Miles	Subsection	States	Targets	Best
1	Baron Fork	38	AR	OK	24	0
2	Big Creek	31	WR	MO	3	1
3	Big Piney River	67	MO	MO	37	7
4	Big River	122	MO	MO	28	1
5	Black River	172	WR	MO	44	4
6	Bonne Femme Creek	15	MO	MO	2	0
7	Bourbeuse River	91	MO	MO	21	0
8	Brush Creek	10	MO	MO	1	0
9	Bryant Creek	39	WR	MO	2	0
10	Buffalo River	137	WR	AR	28	9
11	Castor River	50	WR	MO	21	0
13	Clear Creek	20	MS	IL	1	0
14	Eleven Point River	82	WR	ARMO	38	4
15	Elk River	67.6	AR	MO	30	3
16	Gasconade River	228.4	MO	MO	26	1
17	Huzzah/Courtois Creeks	98.4	MO	MO	2	1
18	Jacks Fork River	33.9	WR	MO	27	2
20	Kings River	60.1	WR	AR	30	2
21	Little Black River	27.1	WR	MO	3	0
22	Little Niangua River	27.8	MO	MO	3	0
23	Little Red River	259	WR	AR	25	4
24	Maries River	32.6	MO	MO	2	0
25	Meramec River	157.7	MO	MO	31	6
26	Moniteau Creek	37.4	MO	MO	14	1
27	Mulberry River	63.7	AR	AR	13	4
28	Niangua River	45.7	MO	MO	22	1
29	North Fork White River	98.4	WR	MO	37	6
30	Osage Fork Gasconade River	66	MO	MO	25	1
31	Osage River	62	MO	MO	20	0
32	River aux Vases	23	MS	MO	1	0
33	Rocky Creek	8.2	WR	MO	11	1
34	Roubidoux Creek	47.7	MO	MO	3	0
35	Saline Creek	25.7	MS	MO	1	0
36	Salt Creek	2.5	MO	MO	0	0
38	Spavinaw Creek	28.5	AR	AROK	16	0
39	Spring River, AR	154.9	WR	ARMO	37	1
40	Spring River	107.8	AR	MOKSOK	40	1
41	St Francis River	63.8	WR	MO	30	2
42	Strawberry River	218.7	WR	AR	26	1
43	Tavern Creek	44.3	MO	MO	2	0
44	Current River	130	WR	MO	35	25
45	Indian Creek	12	WR	ARMO	3	2
46	Bear Creek	11	WR	MO	2	0

Figure 6. Ozarks Ecoregion Watershed Quality Rankings Used to Assess Viability of Aquatic Targets

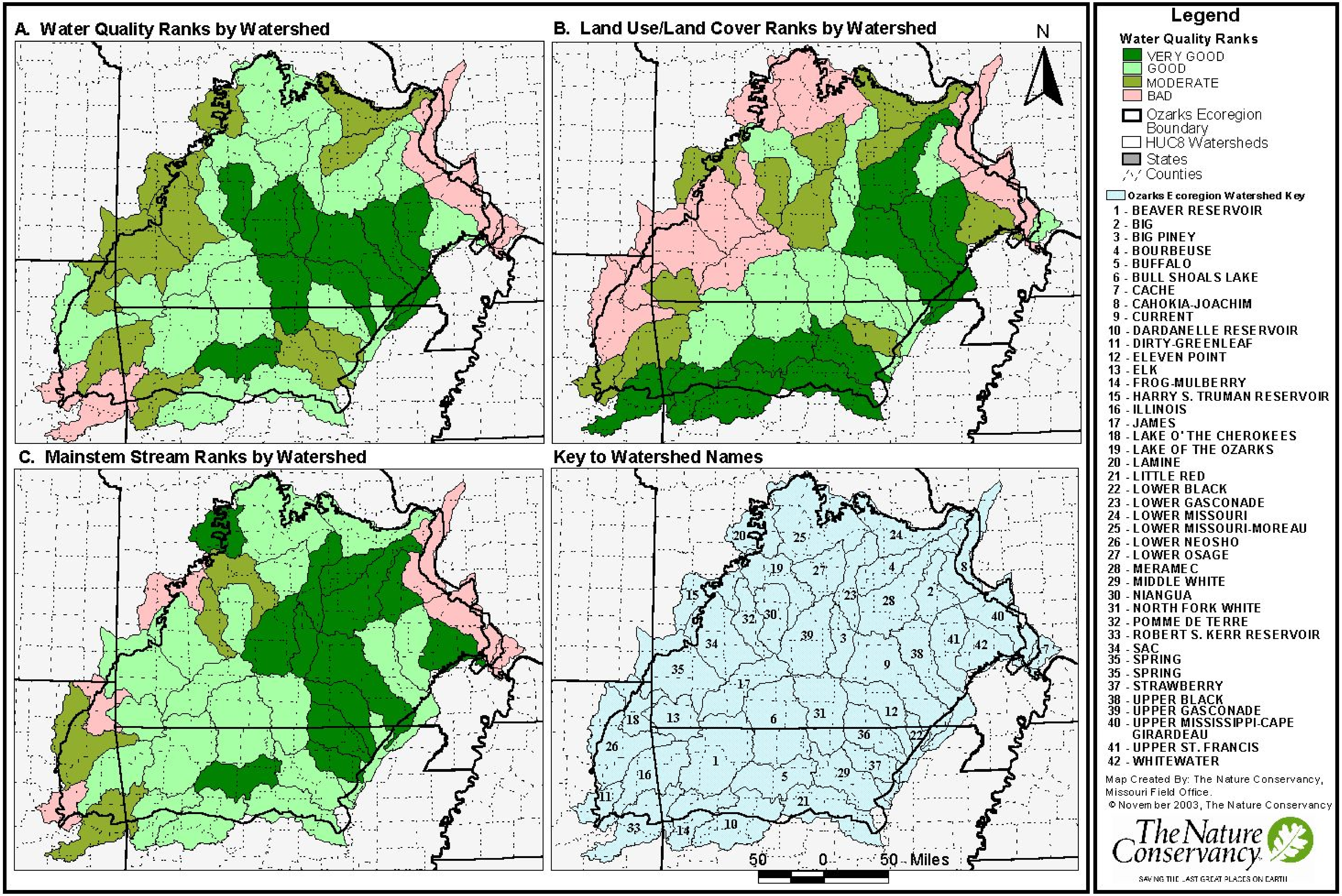
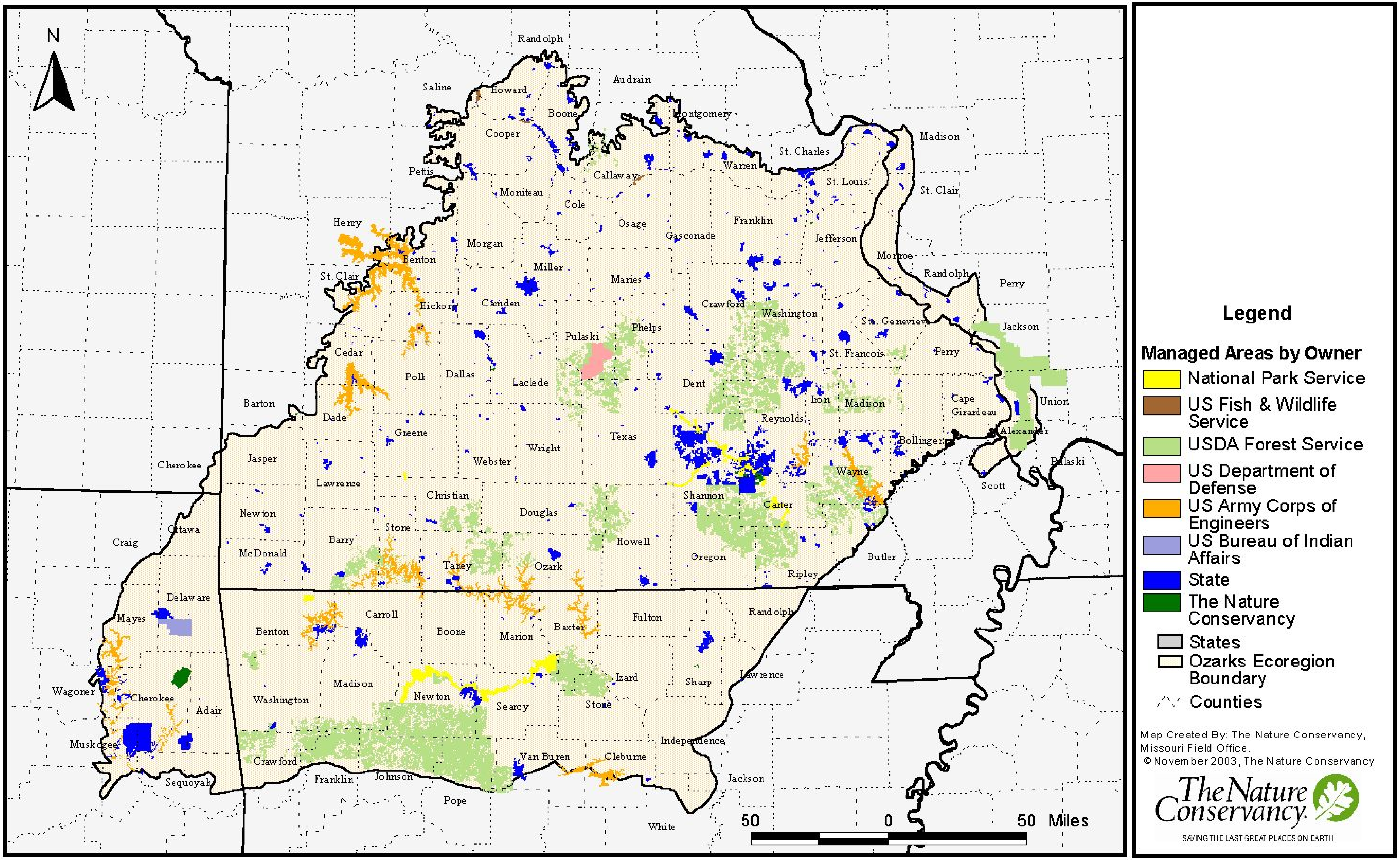


Figure 7. Ozarks Ecoregion Managed Areas



7. Portfolio Assembly and Statistics

The Ozarks ecoregional portfolio (Figure 8) was developed as an iterative assembly process, always attempting to meet conservation goals for all targets as efficiently as possible while maximizing aggregate viability. Portfolio assembly was an additive process to fully integrate each of the target types (terrestrial, surface aquatic, karst). This entailed a series of meetings among the core team and other Conservancy experts to complete a sequence of procedures as described below. During these stages of the assembly process, spatial data sets were projected onto a dry erase board and markers were used to delineate and successively modify portfolio sites as part of an interactive discussion process. Final results for each site were then digitized. Target capture was simultaneously evaluated through each modification and recorded in tabular data sets on completion of each stage of discussion.

1. Aquatic portfolio sites were designated by first selecting all viable occurrences for targets where the total known viable occurrences were required to meet conservation goals. Following this, additional aquatic sites were selected to provide the most efficient target capture of other aquatic targets. This aquatic portfolio was then augmented as needed to include at least one viable, connected stream network system in each aquatic subsection. The resulting portfolio was then reviewed by range of experts in the respective states. The initial aquatic portfolio was adjusted based on comments and information provided through the review process to ensure maximum target capture and efficiency.
2. Matrix natural community selection to meet goals within each terrestrial subsection were made by wherever possible selecting viable occurrences within the watersheds of previously identified aquatic sites. Next, the best examples of viable matrix communities within each terrestrial subsection were selected as needed to meet conservation goals. This process resulted in a series of terrestrial landscape portfolio areas.
3. The resulting portfolio of aquatic sites and terrestrial landscape areas was evaluated for capture of large patch and small patch terrestrial communities. Additional community target occurrences were selected as needed to meet conservation goals and ensure that the best known occurrences of each natural community type were included in the portfolio. The resulting portfolio was empirically assessed for efficiency, and adjusted where possible to secure multiple target occurrences within selected portfolio sites.
4. The resulting portfolio was evaluated for non-karst primary species targets capture, and additional selections made as needed to meet conservation goals for primary species. The resulting portfolio was reviewed and adjusted for maximum efficiency.
5. The above steps resulted in a preliminary Ozarks ecoregional portfolio. As a test, this was screened to assess capture of non-karst secondary species targets. Many secondary species targets have insufficient occurrence data to be effectively considered in the selection process, but preliminary data for those targets for which sufficient data were available indicate that the portfolio largely meets conservation goals for secondary species targets.
6. Karst target occurrence data were aggregated from all available sources and used to determine the five caves in each karst subsection containing the highest numbers of target occurrences. To this were added other karst sites to meet conservation goals for karst species targets. The resulting cave and spring site selections were used to synthesize karst portfolio areas by using known or imputed subsurface recharge boundaries.
7. The aggregate portfolio from this sequence was then assessed for ecological systems capture by subsection within each type (terrestrial, aquatic, and karst).

Conservation goals were verifiably met for 86 of the 270 primary species targets (32%). Conservation goals for an additional 78 primary species targets (29%) were probably met, based on anecdotal and empirical evidence. Taken together with the 26 primary targets for which there are good data and for which all known viable populations were captured, this results in goal attainment or maximum possible progress towards goal attainment for 70% of primary species targets. Of the remaining 80 primary targets species, 73 are identified as having major data or knowledge gaps making assessment of target capture impossible.

Using the ecological systems defined in Table 1, conservation goals for terrestrial ecological systems were met for 16 of the 19 subsections. Conservation goals for terrestrial ecological systems were not met for the Springfield Plain, Prairie Ozark Border, or Mississippi River Alluvial Plain Subsections. In each case, the lack of an extant viable matrix prairie community type precluded goal attainment.

Conservation goals for aquatic ecological systems were met for all aquatic subsections except the Arkansas River aquatic subsection, where dams on the Arkansas River system destroy ecological connectivity of every stream system in the subsection. Conservation goals for karst ecological systems were fully met within all karst subsections in the ecoregion.

Total area of the terrestrial landscape areas is 5.26 million acres. The sixty-one karst areas have a collective total area of 1.24 million acres, but an estimated 65% of this area overlaps with terrestrial landscape areas. If the imputed size of each small scale terrestrial site is defaulted to 500 acres, then the aggregate terrestrial and karst portfolio occupies 5.72 million acres, or less than 16.5% of the total surface area of the Ozarks. Aquatic priority sites encompass 3,179 stream miles, or approximately 19% of the aggregate stream reaches within the Ozarks.

This represents an efficient conservation design, which is presumably due in part to the relatively intact biological landscape of much of the Ozark region. For comparison, the ecoregional portfolio for the Osage Plains/Flint Hills ecoregion encompasses 27% of the ecoregion (TNC 2000b), and is less successful at meeting ecoregional conservation goals.

Assessing success in meeting conservation goals is hindered by the fact that some of the primary species targets and many of the secondary species targets are not tracked, and little occurrence data is available. Thus, as indicated by the comments field for many entries in Appendix 3, a capture rate of '0' may not be indicative that conservation goals were not met. The same is true for small and large patch terrestrial communities, and future iterations of this plan will have to develop a refined method of calculating or imputing capture of untracked and incompletely tracked elements of conservation significance.

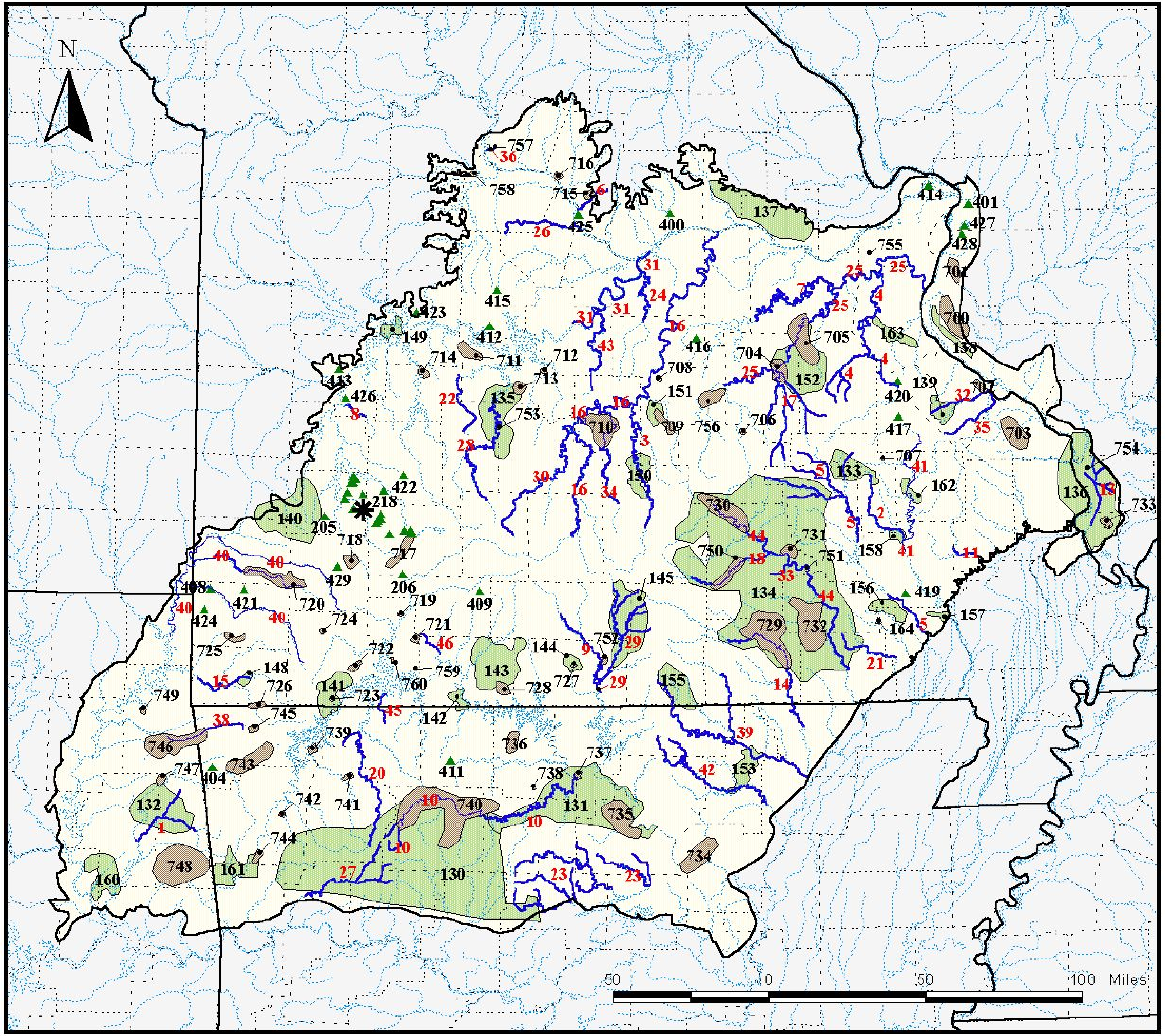


Figure 8. Ozarks Ecoregion Portfolio

Legend

- Aquatic Sites
- Small Scale Terrestrial Sites
- Karst Areas
- Terrestrial Landscape Areas
- Ozarks Ecoregion
- States
- Counties
- Streams

Portfolio Site Names

1 - Baron Fork
2 - Big Creek
3 - Big Piney River
4 - Big River
5 - Black River
6 - Bonne Femme Creek
7 - Bourbeuse River
8 - Brush Creek
9 - Bryant Creek
10 - Buffalo River
11 - Castor River
13 - Clear Creek
14 - Eleven Point River
15 - Elk River
16 - Gasconade River
17 - Huzzah/Courtois Creeks
18 - Jacks Fork River
20 - Kings River
21 - Little Black River
22 - Little Niangua River
23 - Little Red River
24 - Maries River
25 - Meramec River
26 - Moniteau Creek
27 - Mulberry River
28 - Niangua River
29 - North Fork White River
30 - Osage Fork Gasconade River
31 - Osage River
32 - River aux Vases
33 - Rocky Creek
34 - Roubidoux Creek
35 - Saline Creek
36 - Salt Creek
38 - Spavinaw Creek
39 - Spring River, AR
40 - Spring River
41 - St. Francis River
42 - Strawberry River
43 - Tavern Creek
44 - River
45 - Indian Creek
46 - Bear Creek
130 - Boston Mountains
131 - Sylamore
132 - Cookson Hills
133 - St. Francois Mtns
134 - Current River LCA
135 - Western Ozarks Savanna
136 - LaRue/Trail of Tears
137 - Central Missouri River Hills
138 - Fults Hill Prairie Complex
139 - Pickle Creek Complex
140 - Lamar LCA
141 - Roaring River
142 - Drury-Mincy
143 - Ava Glades
144 - Caney Hills
145 - North Fork Hills
148 - Big Sugar Creek
149 - Truman Savanna
150 - Big Piney Hills
151 - Kaintuck Hollow
152 - Meramec Hills
153 - Harold Alexander
155 - White Ranch
156 - Poplar Bluff Pinery
157 - Mud Creek
158 - Mudlick Mountain
160 - Cherokee-Gruber
161 - Garret Hollow
162 - Rock Pile Mountain
163 - Jefferson County Glades
164 - Pump Hollow
205 - Greenfield Glade
206 - Wilson's Creek
207 - Bois D'Arc*
208 - Two Horse Glade*
209 - Roberts Field*
210 - Clear Creek Glade*
211 - Phenix Glade*
212 - Rocky Barrens*
213 - Highway O Glade*
214 - Pertuche Glade*
215 - Corry Branch Glade*
216 - Corry Flatrocks*
217 - Rice Glade*
218 - Eudora Glade
219 - Maze Creek Powerline*
220 - Carmack Branch Glade*
221 - Maze Creek*
222 - Bona Glade*
223 - Flint Hill Glades*
400 - Aux Vasse Glade
401 - Poag Railroad Prairie
404 - Lindsey Prairie
408 - Wildcat Glade Complex
409 - Murphy Pond
410 - Hampton Church Sinks*
411 - Baker Prairie
412 - Little Proctor Creek Fen
413 - Lichen Glade
414 - Pelican Island
415 - Hite Prairie
416 - Ash Pond
417 - St. Joe
419 - Otter Creek Ponds
420 - Coonville Creek
421 - Tree Farm Prairie
422 - LaPetite Gemme Prairie
423 - Rockhill Prairie
424 - Warren Prairie
425 - Bonne Femme Hill
426 - Buzzards Bluff
427 - Horseshoe Lake
428 - Fairmont City
429 - Mount Vernon Prairie
700 - Renault Karst
701 - Columbia Karst
702 - Ste. Genevieve Karst
703 - Perryville Karst
704 - Onondaga Karst
705 - Meramec Karst
706 - Short Bend Karst
707 - Pilot Knob Mine
708 - Cave Ridge Karst
709 - Kaintuck Karst
710 - Waynesville Karst
711 - Climax Springs Karst
712 - Ozark Caverns
713 - Ha Ha Tonka Karst
714 - Cross Timbers Karst
715 - Pierpont Karst
716 - Lewis & Clark Karst
717 - Fantastic Caverns
718 - Paris Springs Karst
719 - Crane Creek Karst
720 - Center Creek Karst
721 - Stutts Karst
722 - Hub City Karst
723 - Radium Spring Karst
724 - Little Flat Creek Karst
725 - Neosho Karst
726 - Bella Vista Karst
727 - Caney Mountain Karst
728 - Tumbling Creek Karst
729 - Eleven Point Karst
730 - Upper Current Karst
731 - Powder Mill Karst
732 - Big Spring Karst
733 - Unimin Mines
734 - Batesville Karst
735 - Blanchard Springs Karst
736 - Dodd City Karst
737 - Buffalo City Karst
738 - Freck Karst
739 - War Eagle Karst
740 - Buffalo River Karst
741 - Withrow Springs Karst
742 - Black Oak Karst
743 - Cave Springs Karst
744 - Devils Den Karst
745 - Bentonville Karst
746 - Spavinaw Creek Karst
747 - Winset Hollow Karst
748 - Stilwell Karst
749 - Jay Karst
750 - Jacks Fork Karst
751 - Beal Karst
752 - Bryant Creek Karst
753 - Coffin Cave CA
754 - LaRue Pine Hills RNA Spring
755 - Rockwoods Spring
756 - Meramec Spring
757 - Salt Spring
758 - Blackwater Spring
759 - Marvel Cave
760 - Bearden Hollow Karst

* = Small scale terrestrial sites too close to identify individually on the map in the starred area.

LCA= Landscape Conservation Area
CA= Conservation Area
RNA= Research Natural Area

Map Created By: The Nature Conservancy, Missouri Field Office.

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8. Threats

In the modern landscape, most areas of biological significance are impacted by factors which have the potential to irreversibly degrade their condition or viability. These factors, termed threats, can be conceptually divided into a *stress* that directly impacts a conservation target and one or more *sources*, which generate that stress. An example would be a stream system with one or more priority biological targets which is being degraded by an influx of sediments. In this case, the stress is sedimentation, and the sources of the stress may be a combination of intensive grazing directly in stream corridors and improperly configured row crop agriculture – two separate sources contributing to a common stress. Similarly, a single source may contribute to multiple stresses. An example of this would be development of confined animal production facilities in a priority area, which would contribute to the stresses of both habitat fragmentation and increased runoff and pollution in a watershed.

For each portfolio site in the region, including aquatic, landscape, small-scale terrestrial, and karst, a threat profile was developed by enumerating the principal stresses and primary sources of these stresses. For each stress at a site these sources were usually ranked in three categories: scope, severity, and irreversibility. These data were then combined into a series of overall threat rankings, resulting in a comprehensive threats analysis for Ozarks ecoregional sites (TNC 2000a). The principal threats to each ecoregional portfolio site with a threat rank of high or very high are included in Appendix 4.

The Ozarks ecoregion is a cohesive unit, with region-wide commonalties among each of several factors, including biological and physical environments, human cultural history, and contemporary societal patterns. Because of this cohesiveness, many of the globally significant ecological sites identified in this ecoregional assessment are afflicted by a common suite of threats, as summarized below.

Aquatic Sites

Four common stresses impact virtually all of the aquatic portfolio sites throughout the Ozarks:

- Hydrological alteration (primary sources: dams and reservoirs, urban development, grazing practices, watershed development).
- Sedimentation (primary sources: grazing practices, conversion to agriculture, road construction/maintenance practices).
- Nutrient loading (primary sources: grazing practices, intensive animal production facilities, septic discharge, recreational activities).
- Habitat destruction (primary sources: grazing practices, agricultural conversion, mining, residential development, road construction/maintenance practices).

Karst Areas

Three principal stresses occur among a majority of karst sites in the ecoregion:

- Subsurface habitat disturbance (primary sources: recreational misuse).
- Sedimentation/nutrient loading (primary sources: agricultural conversion, forestry practices, wastewater influx).
- Habitat destruction of critical surface lands (primary sources: residential/commercial development, conversion to agriculture, forestry practices).

Terrestrial Landscape Areas

Three principal stresses are frequent in large scale terrestrial sites throughout the ecoregion:

- Altered fire regimes (primary sources: fire suppression, forestry practices).
- Habitat destruction/conversion (primary sources: conversion to agriculture/silviculture, grazing conversion, residential development).
- Habitat fragmentation (primary sources: grazing conversion, primary and secondary home development).

Small Scale Terrestrial Sites

Four principal stresses occur among small scale terrestrial sites:

- Habitat destruction/conversion (primary sources: conversion to agriculture, rural residential development, recreational use).
- Habitat fragmentation (primary sources: rural residential development, conversion to agriculture, grazing practices).
- Altered fire regimes (primary sources: rural residential development, resource agency limitations).
- Altered composition and structure (primary sources: invasive/alien species, grazing practices).

Identification of principle common threats for suites of sites across an ecoregion provides a basis for developing and implementing strategies to address multi-site threats in the most effective manner. Within the Ozarks ecoregion, priority multi-site threats to be addressed include the need for more application of fire in critical areas, greater emphasis on planned infrastructure and residential development, particularly from a watershed perspective, and better interaction with forestry, ranching and agricultural constituencies in the development and application of conservation-appropriate production practices.

9. Data Sources and Information Management

The Ozarks Ecoregional Assessment was primarily a GIS-based effort utilizing base map data for states, counties, urban areas, roads, lakes and rivers, conservation ownerships, and target occurrence data from State Natural Heritage programs. Heritage data were supplemented with tabular data for aquatic and karst species from a variety of data sources. These hard data were further supplemented through the use of experts from Natural Heritage programs, universities and agency partners to provide information on the locations, quality, and viability of target occurrences and sites.

Map data were derived from a variety of sources. All map data was transformed into a common map projection of Universal Transverse Mercator (UTM) Zone 15 NAD 83. While not technically the ideal map projection for the Ozarks assessment, this was the most commonly used projection among agency planning partners and best facilitated data exchange among the multi-state, multi-agency core team. Basic base map data such as states, counties, highways, railroads, and populated places was obtained from ESRI Data & Maps software media (1998). Stream coverage was obtained from the 1998 US EPA Reach File 1 (RF1) for the Conterminous United States. Watershed boundaries were obtained from the 1998 US Geological Survey Hydrologic Unit Boundaries of the Conterminous United States. Land Cover was obtained from the US Geological Survey National Land Cover Characterization Project. State coverages were stitched together and re-projected for this assessment by the Missouri Resource Assessment Project (MoRAP). Protected ownership coverage was assembled from: US Fish & Wildlife Service GAP Analysis projects for Missouri, Oklahoma, and Arkansas; ESRI Data & Maps Federal lands coverage; and data from queries of individual state agency and TNC GIS staff ownership files. The Ozarks Ecoregional boundary was obtained from USDA Forest Service. Subsection boundaries were then modified by core team members from Missouri and Arkansas Natural Heritage Program staff to reflect a finer scale of resolution within the ecoregion.

The following State Natural Heritage programs provided species and community occurrence data for the Ozarks Ecoregional Assessment (January 2000 data): Missouri Natural Heritage Database, Arkansas Natural Heritage Inventory, Oklahoma Natural Heritage Inventory, Kansas Natural Heritage Inventory, and Illinois Natural Heritage Database. Species and community Element Occurrence Records (EOR's) were imported into Arc-View as point data and filtered as follows: general, minute, historic, and extirpated EOR's were removed and saved as reference data; all EOR's with last observed dates greater than twenty years (prior to 1980) were removed and saved as reference data; species EOR's for all non-target species were removed; Ozarks Assessment species target attributes (Global Rank, Target Class, and Habitat Code) were added to species EOR's; and all natural community EOR's were crosswalked into the Ozarks Assessment community target associations.

Tabular data for aquatic and karst species distributions were assembled from a variety of sources. Aquatics data were assembled into a table of target aquatic species occurrences by eight digit watershed within the ecoregion. Data from the USDA Forest Service Ozarks-Ouachita Highlands Assessment (1999), MoRAP Missouri Aquatic Gap Project, and a variety of species experts and publications were used to assemble the table. Collections records, published assessments, and many expert opinions were then used to develop viability ranks for each watershed occurrence record. Occurrences not seen since 1980, and occurrences resulting from bait or fisheries stocking introductions were deemed not viable. Additional watershed viability information was obtained from spatial analysis of related geographic data and from the EPA Index of Watershed Indicators with emphasis on water quality metrics.

Karst data for target species distributions were assembled from the Missouri Biospeleological Database (Missouri Department of Conservation), Arkansas and Oklahoma Karst Initiative Database (The Nature Conservancy), the Subterranean Amphipod Database (Old Dominion University), and numerous reports and communications with experts in particular species groups. These data were used to assemble distribution tables and target richness metrics for sites. Hard data on karst species viability and distributions were problematic to assemble for several reasons. Few agency partners maintain cave location information for legal and data protection reasons, many karst species are cryptic and incompletely inventoried, and State Natural Heritage programs are inconsistent with regard to which species are tracked. Expert opinion and model data for cave and spring recharge areas was generously provided by Ozark Underground Laboratory and the Missouri Department of Natural Resources. A combination of multi-site aggregation and recharge area mapping was used to transform karst point sites into karst portfolio areas, adopting the concept of presumptive karst habitat, which assumes that caves and springs are essentially sample points for a larger subterranean area of karst aquatic species occurrences.

Portfolio data were recorded as shape files in Arc-View: Selected RF1 reaches were used to represent portfolio streams; polygon coverages were created for terrestrial landscape and karst areas; and a point coverage created to represent small scale terrestrial sites. This data set of shape files continues to be maintained by the assessment data manager but will likely be transferred to a Conservancy GIS resource office in the future.

Tabular data to support the assessment process was assembled in a series of Excel workbooks for target lists, community associations data, target occurrence and viability data, and site threats data. An Access table was created to track and report target capture information by portfolio site. A clear next step for the tabular data is to move this information into the new Conservation Planning Tool (CPT). Given the size and complexity of this data conversion task, it is likely that a multi-state team approach will again be needed to accomplish this conversion.

Meta data for portfolio coverages and tabular data sets created for this project are found on the data CD for this assessment. The data CD is for internal planning purposes only and contains proprietary and unpublished data from a number of individuals, agencies, and state Natural Heritage programs. Distribution of this data must be evaluated on a case-by case basis and data distributed and/or published only as defined in the meta data on the CD. Subsequent iterations of the Ozarks Ecoregional Assessment will likely have more robust data sets available for target occurrences across state lines as multi-state and multi-agency partnerships continue to develop better information related to karst and aquatic species and habitats.

10. Future Needs

This assessment provides a blueprint to guide biodiversity conservation in the Ozarks ecoregion. It should be regarded as part of a dynamic process of successively more refined iterations as our knowledge of both applied conservation biology and the landscape and biota of the Ozarks continue to develop.

Among key areas to be considered or improved in future iterations of this assessment are the following:

Targets

- Implement a method to track capture of secondary targets, or as an alternative, devising a method of tracking imputed capture of secondary targets through surrogates.
- Continue to aggressively develop refined information for Ozark biota, particularly among cryptic or poorly known organismal groups, and to expand target list accordingly about potential.
- Develop better cave EO data, especially for the Northern Border Karst Subsection, where current data was insufficient to meet selection goal of the five best caves in the subsection.

Occurrences

- Develop better data regarding occurrence, range-wide distribution, and EO ranking data for unranked species targets.
- Develop a consistent data set for secondary target occurrences for the Ozark portions of all states within the ecoregion.

Goals

- Use aquatic gap analysis community classification to test completeness of aquatic community capture.
- Develop and implement a method to identify most viable candidate restoration sites for matrix community targets with unfulfilled conservation goals.
- Develop analysis to identify and prioritize species reintroduction targets and appropriate sites.
- Create unified ecological systems goals incorporating terrestrial, karst, and aquatic systems.

Portfolio

- Fully integrate ecoregional portfolio selections with portfolio data from adjacent ecoregions.
- Address divergence in aquatic portfolio selections between this assessment and the supra-ecoregional assessments underway in the Missouri ands Upper Mississippi rivers.

Data Management

- Transition all data to the Conservancy's new ecoregional data standard, the Conservation Planning Tool (CPT).

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